WHITE PAPER ON SCIENCE AND TECHNOLOGY

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Foreword

Mankind now experiences the historically important world events. In international politics, the East-West cold war structure collapsed at an unexpectedly rapid pace, and this, coupled by the consequent surge of nationalism, compels Japan to restructure its relations with the former East-European countries. Furthermore, we encounter a number of global problems of great significance. These major changes and moves in the world are causing expectations to be placed on Japan. On the other hand, it is also a fact that Japan is apt to be criticized as a "country dependent on other countries in the field of basic research" and also as a "country failing to fulfill its role equal to its national strength".

This year's white paper analyzes the role Japan plays in global scientific and technical activities, and charts its future course to perform its international responsibilities.

It is my wish that this white paper provides useful information to discuss Japan's position in the world as well as its role. At the same time, I would like to stress that the Japanese government will make its best effort to promote Japan's science and technology, including the areas pointed out in this white paper, in such a way as to create a common international asset for mankind.

I ask for your increased understanding and cooperation.

September, 1991

Akiko Santo,
Minister of State for
Science and Technology

Preface

Today, there are increasing discussions about the changing paradigm of science and technology. Because paradigm generally means "framework", these discussions indicate that the framework for science and technology is changing qualitatively.

The rapid globalization of our economic, scientific, and technological activities has revealed that our earth is truly limited. This limitation is becoming more apparent in many areas such as resources, energy, and markets. Recognizing these limitations, we are required to find ways and means of achieving "sustainable development" -- a way of life to enable our activities to harmonize with the environment toward the future. A great deal of expectation is now being placed on science and technology to enable people to live in harmony with one another and with all lives on earth.

At this critical junction for mankind, the theme of this year's White Paper on Science and Technology is "Globalization of Scientific and Technological Activities and Issues Japan is Encountering". It shows recognition Japan will play a significant role internationally in science and technology from now on. We review the globalization of scientific and technological activities in order to see the ways in which Japan will contribute to the world thereby furthering the sustainable development of mankind.

This white paper consists of three parts. Part 1 deals with the aforementioned concept. Part 2 compares scientific and technological activities internationally, and examines the status of these activities in Japan. Part 3 describes measures which have been developed in accordance with the "General Guideline for Science and Technology Policy", the fundamental policy statement of the Japanese Government concerning science and technology.

Part 1. Globalization of Scientific and Technological Activities and Issues Japan is Encountering

The destruction of the Berlin Wall and the ending of the Cold War has accelerated the construction of a new world order. However, the Gulf War, triggered by Iraq's invasion of Kuwait in August 1990, revealed some difficulties attending this construction. In addition, the North-South problem, which has continued for many years between the developing and developed countries, is not easy to solve. Rather, it seems that economic gaps, which increase the difficulty in attaining future world stability, are expanding (Table 1-1-1). Moreover, our planet earth has many problems which need to be solved -- in areas such as global environment, population, resources, and energy. The nations of the world must meet these challenges with our collective wisdom; we must concentrate our efforts on solving these problems.

Japan's economic scale ranks second in the world and Japan's scientific and technological capability is well recognized. Because science and technology will provide possibilities for solving many of these problems, it is in this direction that Japan must proceed to make its international contribution.

By nature, scientific knowledge flows back and forth across national borders. In these years, caused by the rapid scientific and technological development, movement of technology that are apt to be considered proprietary also activated by the increase of technology, trade and international direct investment. As a result, activities in the domain of science and technology are moving beyond the traditional framework of

Table 1-1-1. Relationship between world situation and science & technology

	Late '80s	90's
World structure	End of cold war between the east and the west (Relevance:Superiority of information and electronics technology in market economy)	Concern about polarization. Widening gap between the north and the south (Challenge: technical assistance to developing countries)
Economic activities	Expansion of borderless activities (Relevance: technological innovation encouraging international exchange.	Transfer to economic structure which ensures protection of global environment (Challenge: expectation that science and technology will harmonize with the environment)

Source: Science and Technology Agency (STA)

bilateral cooperation to complex mutoal dependent relationships among countries. Cooperative relationships are occurring where the world's scientists and engineers unite to promote research and development of solutions to global problems. This white paper titles this kind of global activity and inter-dependency in science and technology among the world's countries as "Globalization of scientific and technological activities". Part 1 examines the current status of globalization and Japan's current position, and seeks to define Japan's future direction and the roles the country should perform in the international community.

1.1. Development of Globalization

1.1.1. Expansion of Economic Activities Across National Borders

1.1.1.1. Global Expansion of Economic Activities

As shown by rapid increases in trade, overseas investment, and foreign security trading, national economic activities now have global implications; economies have become more interdependent. The annual growth of world trade has exceeded the world's net economic growth since the mid-80's. Services (such as transportation, travel, financing, insurance, patent royalties and consulting) are characteristically consumed at the same time as they are produced and thus not thought of as important elements of international trade, resulted in a 14% average annual growth in five years from 1985 to 1989, reflecting the closer economic ties between countries (Figure 1-1-2). This exceeded the growth of the goods trade. Also, overseas direct investment has been expanding rapidly after the exchange rate adjustments resulting from the Plaza meeting in 1985. The expansion of direct investment can be seen in the figures of investment flows among the world's three major economic centers (i.e., the US, Japan and the EC) during the period from 1985 to 1989. The amount of Japanese and EC investment in the US has grown extraordinarily (Figure 1-1-3).

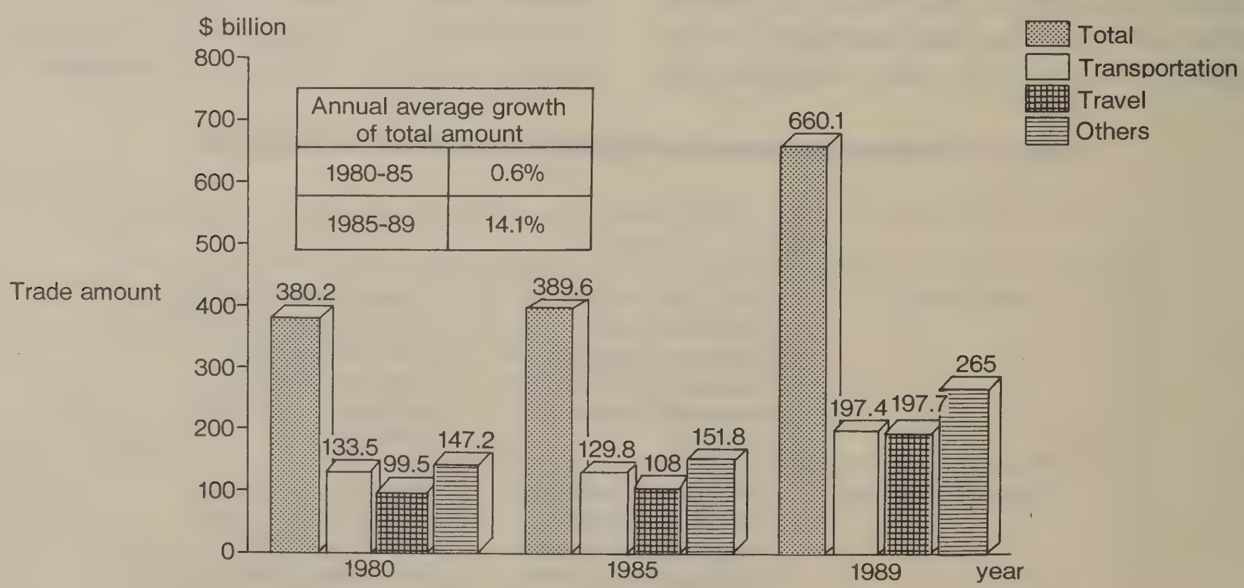


Figure 1-1-2. Trends in world service trade

Source: White Paper on International Trade 1991
Citation: IMF "Balance of Payments Statistics"

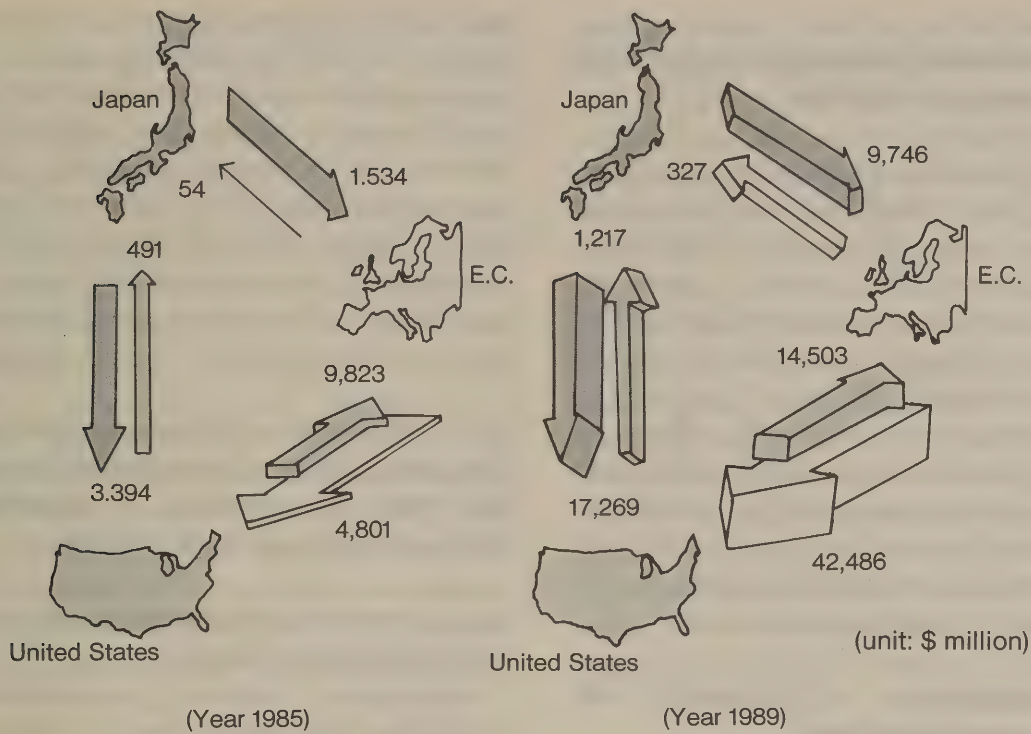


Figure 1-1-3. Flow of direct investment between Japan, US and EC

Note: Figures for EC: Sum of 10 countries for 1985 and 12 countries for 1989
Compilation: Science and Technology Agency
Source: US Department of Commerce "Survey of Current Business" for the flows between the US and Japan, and between the US and the EC. Japan's Ministry of Finance "Monthly Statistics of Finance" for the flow between Japan and the EC.

Factors encouraging these activities include worldwide deregulation and detente between the East and West, development of information/communication technologies including highly-advanced computer networks, and improved traffic/transportation systems. The rapid expansion of direct investment is caused by active private sector activities which have been expanding beyond national borders, reflecting a growing demand for high value-added products meeting diversified market needs throughout the world. These direct investments influence trade flow and contribute to the adjustment of trade imbalances through reverse imports, advancement of host nation industries, and enhanced competitiveness.

1.1.1.2. International Adjustment of Economic Activities

Increasing globalization of economic activities generally favorably influences the development of the world economy, but greater interdependence means that national policies increasingly affect the activities and policies of other countries. This makes it necessary for national economic and political interests to be adjusted among countries. Efforts have been made to form a stable international order through correcting of restrictive trade measures at the GATT, cooperating in economic policies at the Economic Summit Talks, and cooperating on international financial policies in the G-7.

1.1.1.3. International Coordination in Scientific and Technological Activities

As local production increases through direct investment, local R&D facilities have been established to meet market needs, in addition to sales and production centers. Increasing globalization of economic activities has resulted in the same tendency not only in scientific but also in technological activities. This has been accompanied by problems caused by differences in national administrative systems and science and technology practices, e.g. different treatment of intellectual property rights and technology standardization. Solving these differences will require close international cooperation.

1.1.2. Globalization of Scientific and Technological Activities

Japan has been using technological progress as a driving force for its economic growth and for the internationalization of its economic activities. These technological advances were the rapid development of information/electronics technologies starting in the 1970s, and the nation's positive approach toward technological innovation which combined communication and computers in the 1980s. While Japan's economic prosperity benefits from science and technology, we should not forget that achievements in basic research in Europe and the US have played a significant role in the development of science and technology. Results obtained through long-term investments by mankind into basic research activities provided a common basis for S&T development worldwide. Now in this paper we are starting to deal with the current status of globalization in science and technology and the relative standing of Japan.

In this section, the level of basic research and technology is at first compared internationally. Then, science and technology indicators (human resources, papers, information, patents, technology trade, etc.) are examined to assess the progress of S&T globalization and to study Japan's position and the role Japan plays in the global context. Also, the scientific and technological activities at public research institutes and private corporations are analyzed from a global point of view. Furthermore, international cooperation on those issues which require joint effort, such as global environment issues and "mega-science", will be reviewed.

1.1.2.1. The Position of Japan's Science and Technology in the International Community and the Development of International Exchange as Seen from Indicators

1.1.2.1.1. International Comparison of Scientific and Technological Levels

Increasingly, national governments are recognizing the importance of science and technology, and are promoting policies dealing with science and technology activities. Consequently, there has been heightened interest in comparisons of national science and technology levels. In the US, the Departments of Commerce and Defense have presented comparative studies of promising, future, key technologies. Their efforts are designed to result in more focused science and technology policies.

Before discussing the globalization of scientific and technological activities, this White Paper will describe the levels of achievement of various countries in the areas of basic research and technology.

1.1.2.1.1.1. Basic Research

The number of Nobel prize laureates is often used as an indicator of the level of basic research. Forty percent of the Nobel prize laureates are from the US. The UK is second, followed by Germany and France. Japan is ranked in the 12th position, with only 5 laureates so far. Based on these figures, some have argued that Japanese people lack creativity and that Japan has a weak foundation in basic science. The number of

Nobel prize laureates, however, is only one index of basic research activities, but it does not necessarily reflect the present level of basic research activity, because the prize is awarded based on past achievements.

While it is difficult to evaluate objectively each country's level of basic research, surveys were conducted by the Science and Technology Agency of how researchers assess these levels comparatively. The latest survey (Survey of High-tech Researchers and Engineers, in FY1991) was conducted in May 1991, and solicited the views of Japanese researchers about the levels of basic research in Japan, the US, and Europe. Questionnaires were sent to 1,012 public, academic and private sector researchers (531 responded) in the fields of life sciences, materials, information/electronics and marine/earth sciences. According to the results of the survey, the respondents viewed the US as superior in almost all basic research areas. Many respondents commented specifically that the US is in a superior position in the life sciences and in marine/earth sciences. In a similar survey conducted three years ago, respondents viewed Japan and the US as equal only in one subject area, and the US as excelling in the eleven others. In this year's survey, researchers replied that Japan had reached parity with the US in 3 subject areas but that the US excelled in the remaining nine. This indicates that the level of Japan's basic research may have improved a little in the past three years (Table 1-1-4).

In comparison with Western Europe, the survey three years ago indicated that Japan was superior to Western Europe in 4 subject areas,

Table 1-1-4. Relative standing in emerging technologies: Japan vs U. S.
International comparison in basic research

Field	Research theme	Japan vs US		Japan vs Europe (E)	
		3 years ago	present	3 years ago	present
Life sciences	Elucidation of gene expression control mechanisms	US	US	E	=
	Elucidation of the process of growth and aging	US	US	E	E
	Elucidation of brain functions	US	US	E	E
Materials	Exploration of new phenomena on surface/interface of materials	US	US	=	=
	Research on the creation of new and highly functional materials by controlling crystalline structure	=	=	Japan	Japan
	Research on theoretical material design methods	US	US	=	=
Information /Electronics	Creation of highly functional devices controlled at molecular and atomic levels	US	=	Japan	Japan
	Super distributed and parallel data processing	US	US	Japan	=
	Research on the extraction of semantic information from audio-visual data	US	=	Japan	=
Ocean/Earth	Research on the global ocean circulation and the interaction between the atmosphere and the ocean through the investigation of various phenomena in the ocean	US	US	E	=
	Research on the ecological system in the ocean	US	US	E	=
	Research on the long-term change of air temperature through the monitoring of carbon dioxide, ozone, etc.	US	US	E	=

Note: Country (area) named shows superior one.
Source: Science and Technology Agency "Survey of High-tech Researchers and Engineers, FY1991"
Science and Technology Agency "Survey of High-tech Researchers and Engineers, FY1988"

Western Europe was superior in 6 areas, and both were equal in 2 areas. In the 1991 survey, Japan was thought to be superior in 2 areas, Western Europe in 2 areas, and both were viewed as equal in 8 areas. On the whole, Western Europe was perceived as a little bit superior three years ago, but currently both are almost equal. By research field, Western Europe is seen as superior in life sciences, Japan is seen as superior in materials and information/electronics, and both are viewed as equal in marine/earth sciences.

These survey results indicate that Japanese researchers perceive Japan's basic research level has improved in the international context during the past three years. This is due to efforts of Japanese researchers. In the 1991 survey, to the question: "Do you think that Japan will come to create new concepts and/or new research areas through efforts in basic research?", 63% of the respondents answered "Yes," twice as many as the 32% of respondents who replied "Not likely" or "Don't think so" (Figure 1-1-5). This indicates a good deal of expectation by Japanese researchers toward the results of Japan's basic research activities.

1.1.2.1.1.2. Technology

In the spring of 1990, the US Department of Commerce published the results of a survey of US experts about present and estimated future levels of achievement of the US, Japan, and Western Europe in 12 emerging technologies, considered to be very promising in the 90s. In the 1991 survey aforementioned, STA has made a similar survey of researchers in the same emerging technology areas (Table 1-1-6).

In the US DOC survey, the US respondents answered that Japan is superior in 5 areas, the US in 6 areas, and the two countries are equal in one area. According to the STA survey, the Japanese researchers responded that Japan's level is superior in 3 subject areas, the US in 4 areas, and they are equal in 5 areas. US respondents tended to regard one country or the other to be superior rather than giving both equal credit. It can be generally said, however, that the present technological levels of the US and Japan are recognized as being almost equal. By technological area, both surveys indicated that the US is superior in the life sciences, and the two countries are even in "super-conductivity".

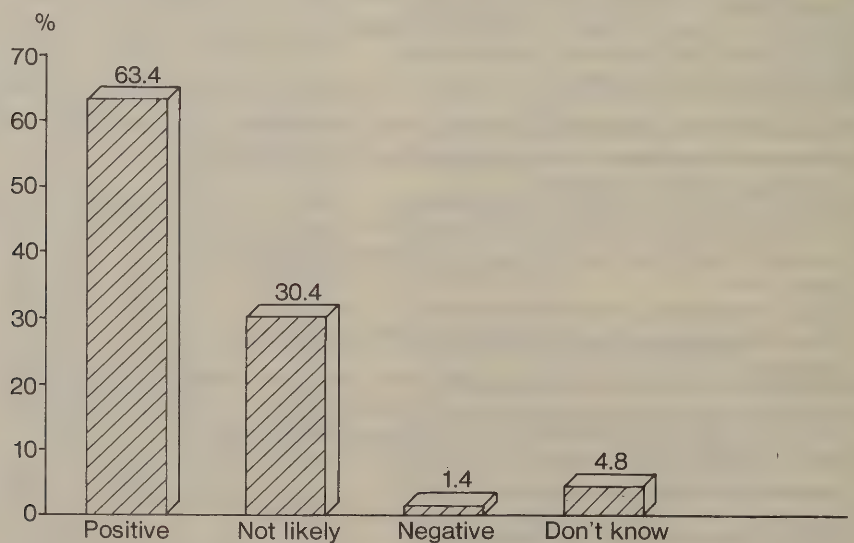


Figure 1-1-5. Is it possible for Japan to create new concept and/or new research fields?

Source: Science and Technology Agency "Survey of High-tech Researchers and Engineers, FY1991"

Table 1-1-6. Relative standing in emerging technologies: Japan vs U.S.

Emerging Technologies	STA's survey		US DOC's survey	
	Current Status	Trend	Current Status	Trend
(Life sciences)				
Biotechnology	🇺🇸	↑	🇺🇸	↑
Medical devices and diagnostics	🇺🇸	↑	🇺🇸	↑
(Materials)				
Advanced materials	=	↑	🇯🇵	↑
Superconductors	=	↑	=	↑
(Information Systems, Electronics)				
Advanced semiconductor devices	🇯🇵	↔	🇯🇵	↑
Digital imaging technology	=	↑	🇯🇵	↑
High-density data storage	🇯🇵	↔	🇯🇵	↑
High-performance computing	🇺🇸	↑	🇺🇸	↑
Opto-electronics	=	↑	🇯🇵	↑
(Manufacturing Systems)				
Artificial intelligence	🇺🇸	↑	🇺🇸	↔
Flexible computer-integrated manufacturing	🇯🇵	↔	🇺🇸	↔
Sensor technology	=	↑	🇺🇸	↑

Note: 1. Current status: Flags show countries ahead.
=means even.
2. Trend: ↑ Japan Gaining
↔ Holding

Source: Science and Technology Agency; "Survey of High-tech Researchers and Engineers, FY1991"; US Department of Commerce "Emerging Technologies, Spring 1990".

In information/electronics, Japan is superior in "advanced semiconductor devices" and "high-density data storage", but the US is superior in "high-performance computers", and "artificial intelligence". A notable difference between these two surveys is that according to the US DOC survey, the US is superior in "flexible computer-integrated production systems", but the STA Survey results indicated that Japan is superior in the same area -- an interesting difference of opinion.

What is the future of these levels of emerging technologies? According to the US DOC survey, the respondents anticipated that the US superiority in "artificial intelligence" and "flexible computer-integrated production systems" will remain, but they predicted Japan's relative level in other areas will improve in the future. According to the STA Survey, the respondents anticipated that the Japan's superiority in "advanced semiconductor devices" and "high-density data storage" will remain, but they predicted also that Japan's relative position in other areas will improve in the future.. While there are some differences in these two surveys regarding the areas in which achievement levels are expected to remain the same, both surveys indicate that Japan's technology progress is on a rising curve relative to the US. Nevertheless, in Japan, there is concern with the decreasing quality of the research environment, such as the national research institutes and the university laboratories. And also the sharp decline in the number of younger people and a tendency of younger peoples' less interest in science and technology are concerned.

For any country, it is essentially important to grasp not only its own level of science and technology, but also that of other countries as well, in order to develop effective policies guiding scientific and technological activities. According to the surveys mentioned above, Japanese and US researchers have a roughly similar perception about the technology levels of the two countries. Such common ideas and recognition shared not only by researchers but also by many others, including policy makers, will help avoid unnecessary friction between countries. Thus, it is important for each country to obtain an objective idea about its own levels of science and technology, and in some case, it is useful to conduct joint surveys and to exchange information. In any case, Japan's S&T policy needs to be based on the recognition that its science and technology levels of achievement have been on a relatively rising curve.

1.1.2.1.2. A Statistical Picture of International Exchange

Needless to say, international exchange plays a great role in the development of science and technology. According to the aforementioned survey, chances for Japanese researchers to communicate with their counterparts in other countries have increased compared with three years ago. Compared with the active communication between the US and Europe, however, Japan-US and Japan-Europe exchanges result in noticeably less exchange of information and researchers.

As for the reasons hindering exchanges, almost 40% of the respondents replied that the "high cost of exchange activities and limited funds" is putting a brake on the "exchange of researchers". This factor was thought to be more influential than the other factor: "Being not involved in an international researchers' network" (Figure 1-1-7). On the other hand, the reason for hindering "information exchange" was attributed by most respondents to the factor: "Being not involved in an international researchers' network", rather than to financial reasons. The same factor rather than financial reasons was pointed out by most respondents also as the reason for hindering the contribution of "international joint-work treaties". The financial obstacle to "joint research" was pointed out by more than 30% of the respondents, but more researchers pointed out the lack of access to an international researchers' network. In

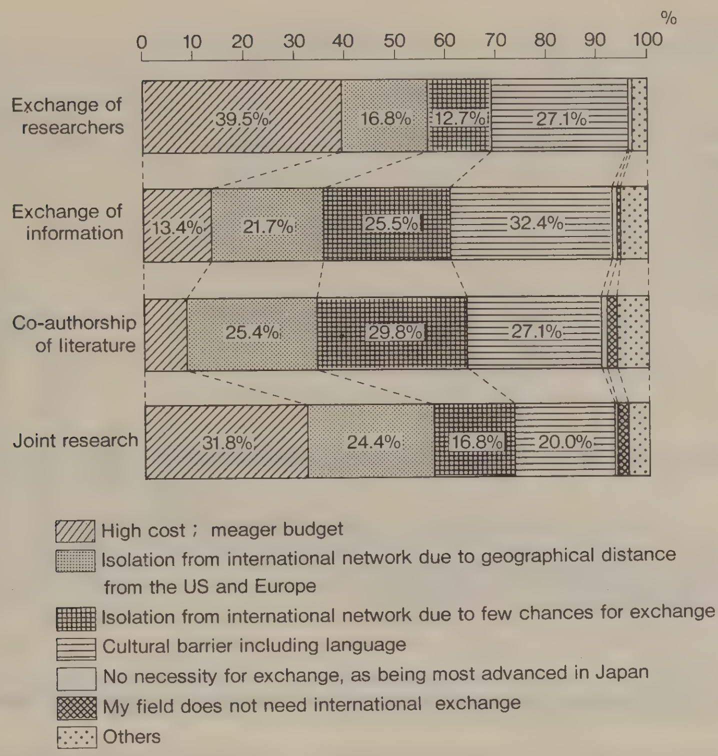


Figure 1-1-7. Factors hindering international exchange

Source: Science and Technology Agency "Survey of High-tech Researchers and Engineers, FY1991"

general, Japanese researchers feel that they are not making an effective part of international researchers' networks -- a fundamental problem affecting research activities in Japan.

1.1.2.1.2.1. Personnel

(1) Exchange of Researchers/Engineers

Of all indicators, the international exchange of researchers/engineers[1)] indicates most clearly the status of the internationalization of scientific and technological activities.

Researchers/engineers who left Japan for other countries in the past 20 years numbered 730 thousands (0.9% of total Japanese travelers abroad). In the same period, foreign researchers/engineers who came to Japan were 460 thousands, showing that more Japanese researchers/engineers visited other countries than foreign counterparts came to Japan. In recent years, both the visitors from and to Japan have been increasing. In 1989, almost 150 thousands went overseas and over 80 thousands came from overseas (Figure 1-1-8). Both figures have been rising steadily after 1985, with the number of departures increasing more rapidly than the number of entries, thus expanding the difference between them. International exchanges of personnel in science and technology have been exceeding the growth rate of the total number of travellers from and to Japan.

By country, the largest number of Japanese researchers/engineers, 70 thousands (48%), went to the US, followed by 14 thousands (9%) to the

1) "Researchers/engineers" here refers to those who leave Japan for the purpose of scientific study, research and training abroad, or those who enter Japan for the purpose of study, training, teaching, scientific research and for providing high level technology.

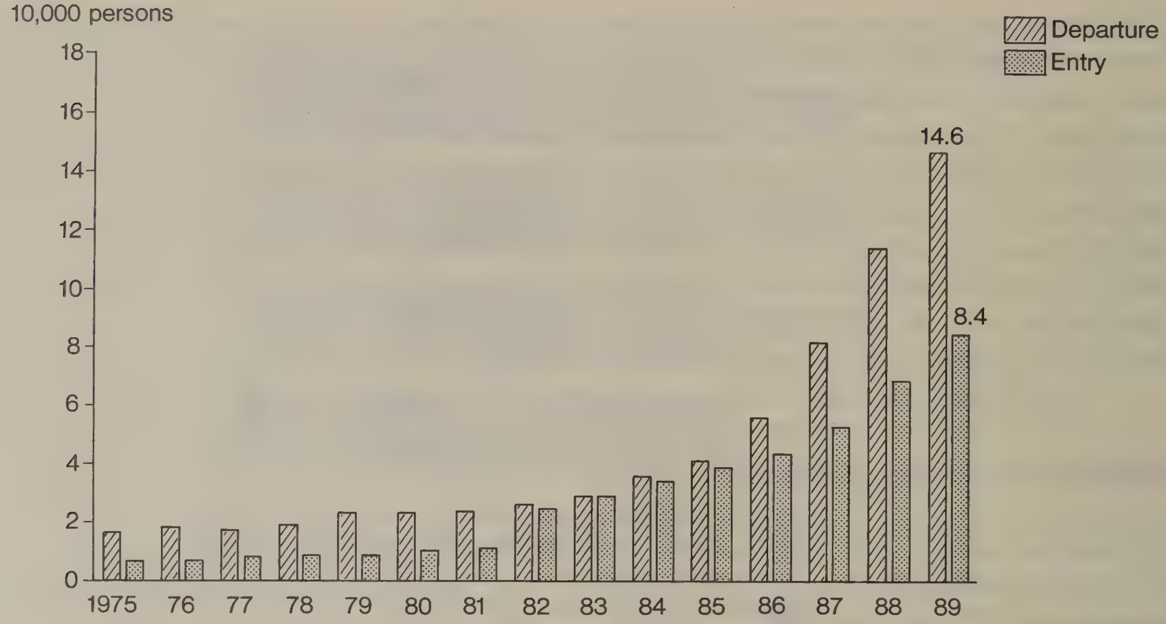


Figure 1-1-8. Trends in departure from and entry into Japan of researchers/engineers

Notes :1. Number of departures based on the purpose of the travel indicated in the emigration card (research, study, technical training). Number of entries based on the data of those screened and qualified to stay in Japan in accordance with the Law of Legal Emigration and Recognized Refugees (study, training, teaching, artistic activities, provision of high level technology).

2. The sharp increase of entry in 1982 reflects addition to the statistics of the entries for the purpose of training.

Source: Ministry of Justice: "Annual Report of Statistics on Legal Migrants for 1989"

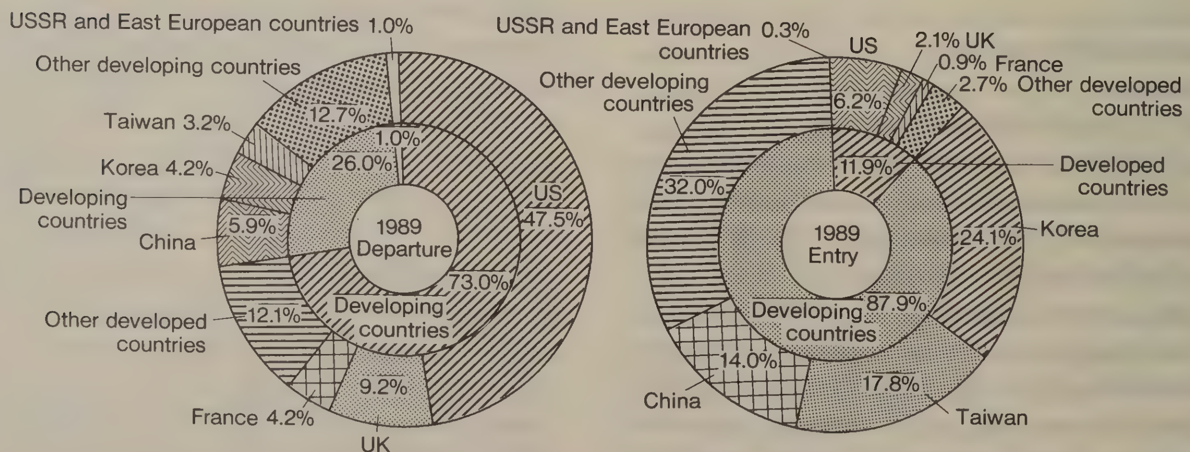


Figure 1-1-9. Breakdowns of researchers/engineers going out from and coming into Japan

Source: Ministry of Justice: "Annual Report of Statistics on Legal Migrants for 1989"

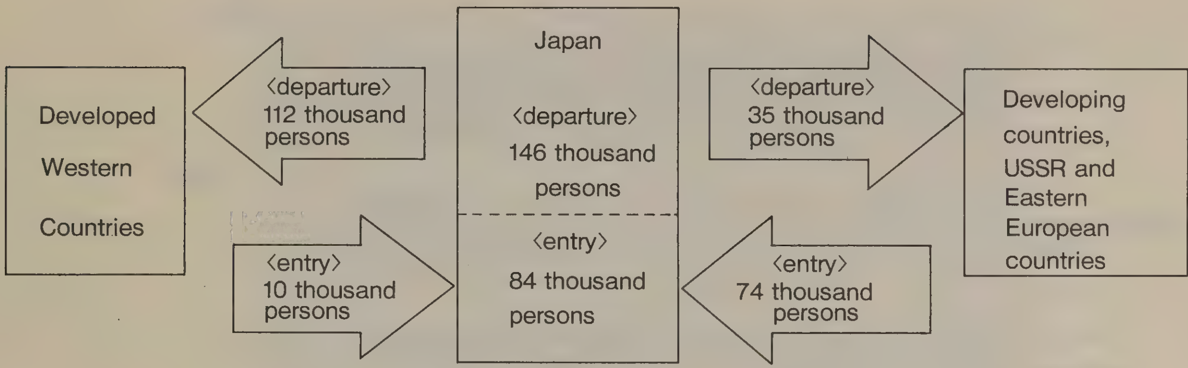


Figure 1-1-10. Researcher/engineer exchanges between Japan and other countries (1989)

Source: Ministry of Justice: "Annual Report of Statistics on Legal Migrants for 1989"

UK and 6 thousands (4%) to France. Of the foreign researchers/engineers who entered Japan, 20 thousands (24%) came from Korea, 15 thousands (18%) came from Taiwan, and 12 thousands (14%) from China (Figure 1-1-9). The ratio of Japanese researchers/engineers who went to developed countries to the researchers from those countries who came to Japan was 6:1 in 1986. In 1989, however, 112 thousands went out but only 10 thousands came in, making the ratio 11:1, indicating a widening gap between the departures and entries. Those coming from developed countries have actually been increasing, but Japanese researchers going out have increased much faster. With developing countries, the ratio was 0.5 in 1986. Three years later, i.e., 1989, the ratio remained the same; the number of departees increased to 35 thousands and incomers to 74 thousands. This shows that the opportunities for exchange increased sharply (Figure 1-1-10). The statistics indicate that a large number of researchers/engineers are coming to Japan from developing countries, but Japanese researchers/engineers prefer to go to developed countries.

According to the "Survey of High-tech Researchers and Engineers" many host Japanese researchers who accepted foreign researchers and trainees from developing countries stated: "Activities in Japan contributed to the developing countries' advancement through technological transfers". However, others replied that Japan's technology is not useful to developing countries, because: "Knowledge obtained in Japan is too advanced", "it does not match the local needs of developing countries" (Figure 1-1-11).

1.1.2.1.2.2. Published Papers[2)]

(1) Number of Papers

The number of papers published in major scientific journals in the world has increased by as much as 45% in the past 10 years. During this period, Japanese researchers have published twice as many papers as before, exceeding the world's average growth figure in most of the research fields. Papers written by Japanese researchers account for 7.7% of the total in 1986, a 1.3 times larger share than 10 years ago. (Figure 1-1-12). By country, the US has been producing more than 30% of the world's total since 1973, but its share has been decreasing slowly. Japan's production was in the sixth place in 1973-1975,

2) We used database which consists of major scientific journals in the world. Therefore, it should be noted that the database does not cover all the papers in the world, and that data on Japanese scientific literature is comparatively limited.

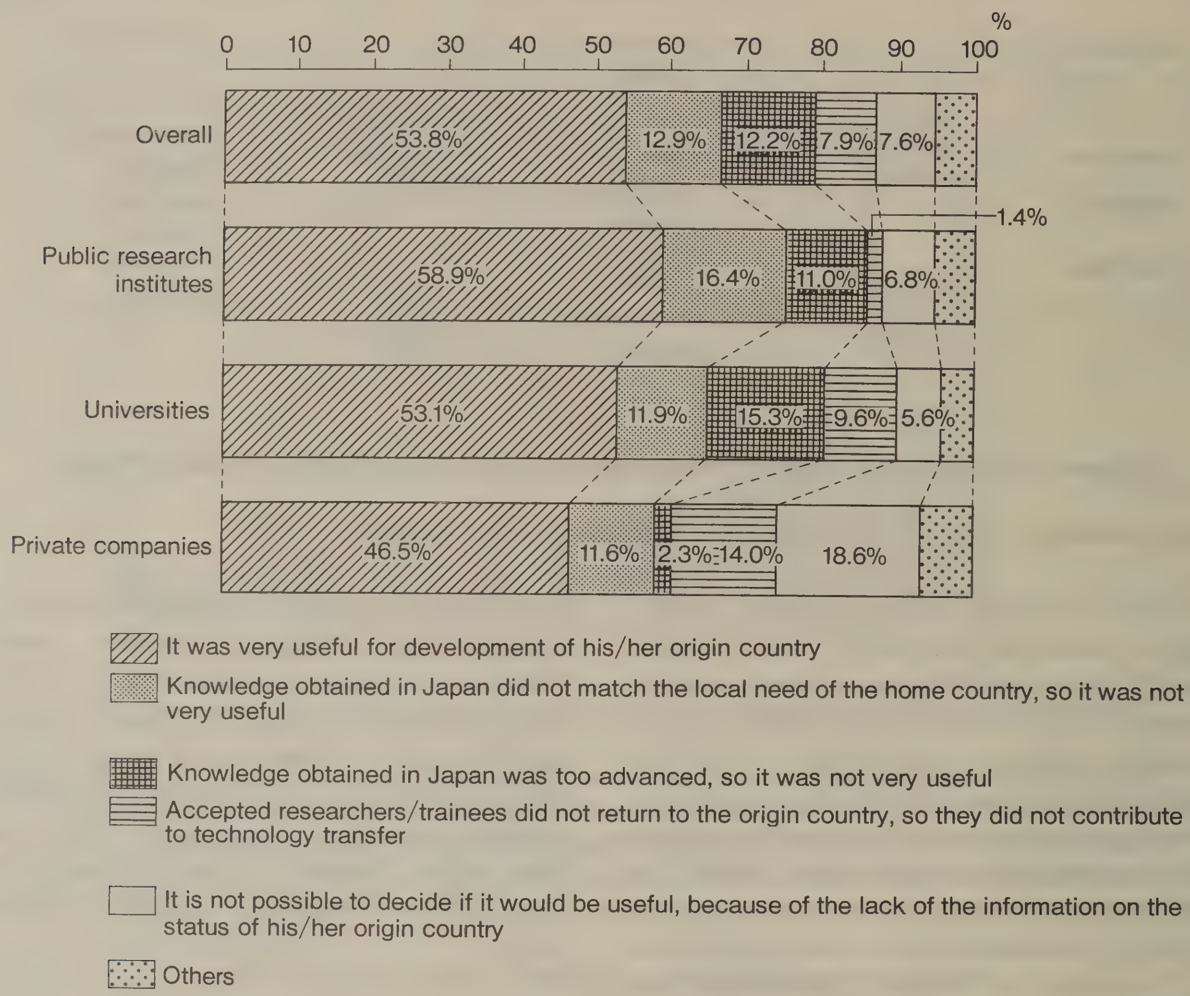


Figure 1-1-11. Acceptance of researchers/engineers from developing countries and technology transfer

Source: Science and Technology Agency: "Survey of High-tech Researchers and Engineers, 1991"

but rose to third place in 1986, following only the US and the UK. The total number of Japanese researchers is larger than the number of British, German and French researchers combined and is increasing rapidly. This is considered to be one of the factors behind the increasing number of Japanese papers. Nevertheless, the number of papers produced per Japanese researcher in 1986 was 0.08, the smallest figure among the five major countries and less than one-third of the UK figure (Figure 1-1-13). Two reasons for this low production rate are -- the analysis was based on the number of papers published mainly in the English language and, in Japan, a greater percentage of researchers belong to private companies.

In the field of life sciences, data on the human genome is considered to be the key to elucidating organic functions. In comparing human genome data published by researchers of various countries, US researchers published the largest volume, followed by those from the UK, France and Japan. Judging from this, Japan's level of contribution in this field is not very high. The need for international cooperation in analyzing the human genome has been recognized, and

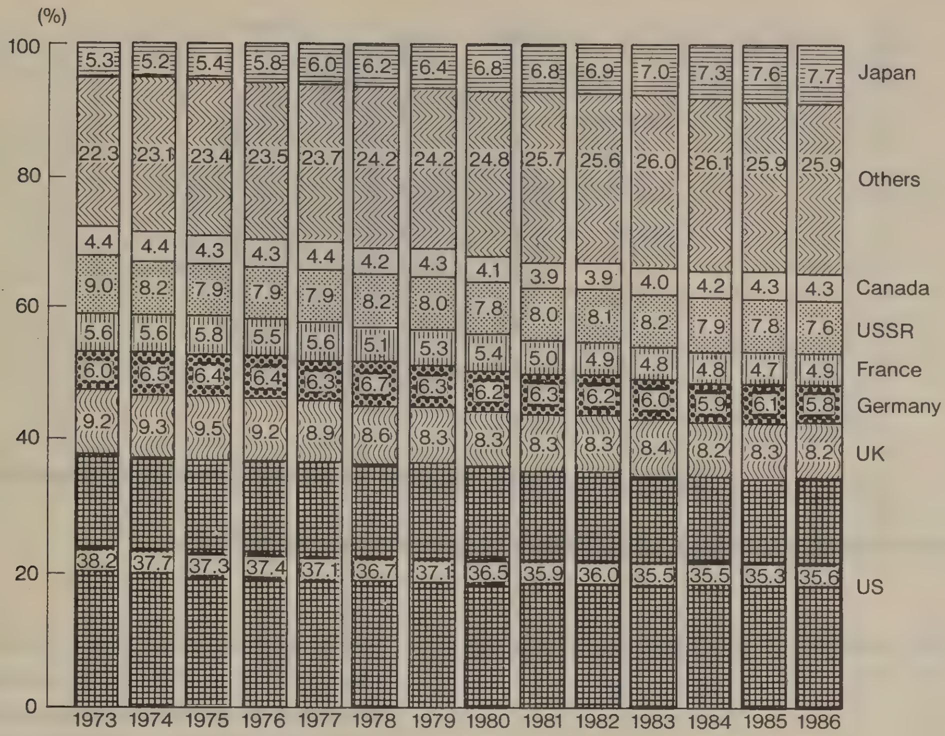


Figure 1-1-12. Changes in published papers by country

Source: National Institute of Science and Technology Policy, STA "Japanese S&T Indicator System"
Citation: Computer Horizons, Inc., "Science & Engineering Literature Data Base, 1989"

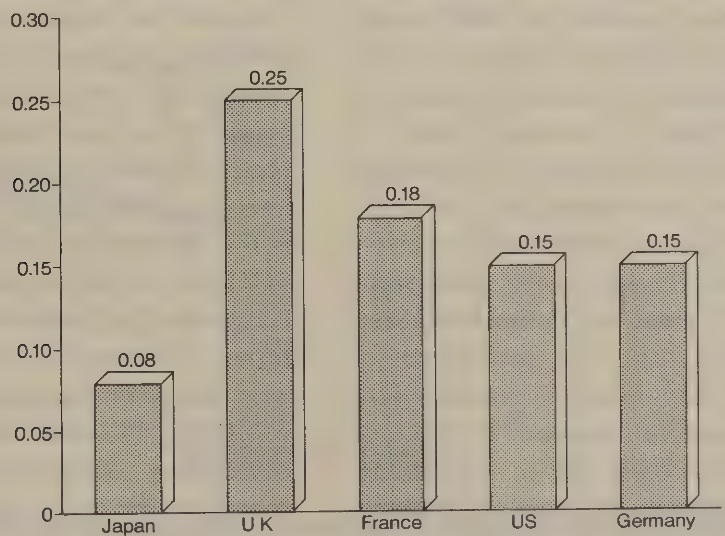


Figure 1-1-13. Number of papers produced per researcher (by country; 1986)

Source: Computer Horizons, Inc., "Science & Engineering Literature Data Base"
OECD data on a full-time equivalent basis (number of researchers)
Compilation: Science and Technology Agency

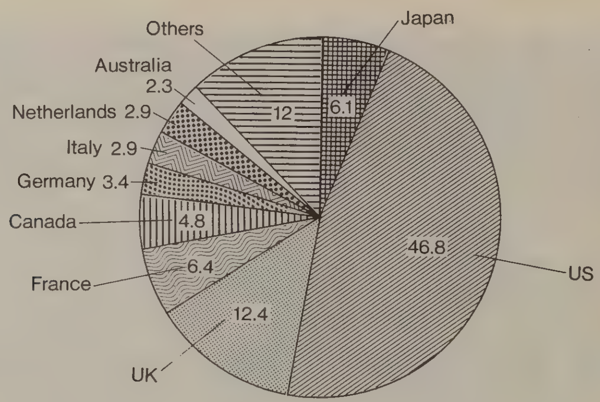


Figure 1-1-14. Publicized data on human genes by country (%)

Source: European Science Foundation: "Report on Genome 1991"

Japan is required to support efforts in this field (Figure 1-1-14).

(2) Citations

Another indicator of a nation's success in R&D activities is the quality of its published papers. Citations of a published paper by other papers indicates the first paper's impact in the research field. Figure 1-1-15 shows relative frequency of citation (the share of number of cited papers divided by shares of published papers), which reveals the relationship between the share of citations and the share of published papers of several countries including Japan. The 45 degree diagonal line in the graph shows that the share of papers and the share of citations is equal.

Papers from the US have been cited most frequently. The US share of citations has been decreasing recently, and its percentage of published papers has been decreasing also, resulting in the relative frequency of citations almost leveling off. With British papers, the share of citations exceeds the share of published papers indicating that the influence per paper is high. However, the relative frequency of citations of British papers has been declining. Japanese papers are cited more often than German and French papers, placing Japan in third place. However, the relative frequency of citations has been rather small, resulting in a lower power of influence of each paper compared with that of the US, Germany and UK. Recently, the number of times Japanese papers have been cited has increased remarkably, making the relative number of citations approximately one per paper in 1986. The citation frequency of USSR papers is extremely low compared with the total number of papers published.

As for the frequency of citation of domestic and foreign papers in each country, while US researchers cite American papers the most, researchers of other countries cite foreign papers more than those written by researchers in their own countries. This is reasonable because the US is the world center of R&D activities (Left part of Figure 1-1-16). As for the numbers of papers being cited by foreign and domestic papers - the former numbers are more significant. Those written by US researchers are cited the most worldwide, followed by those written by British researchers. When Germany and Japan are compared, the total number of papers being cited is more in Japan. However, concerning the citation from abroad, German papers are more often cited. (Right part of Figure 1-1-16). Considering the fact that Japanese researchers publicize more papers in overseas publications than German researchers, these statistics indicate

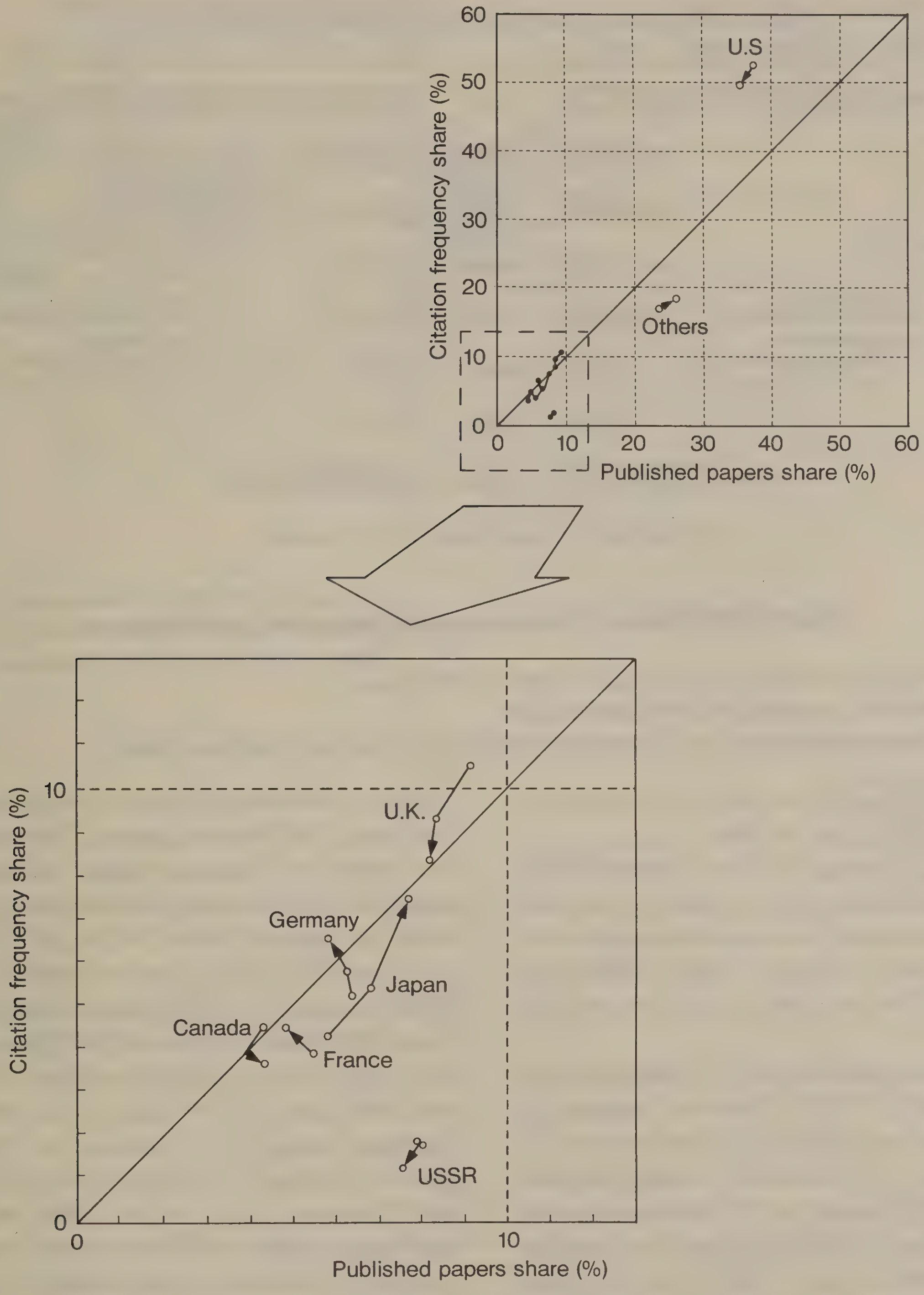


Figure 1-1-15. Changes in relative frequency of citation of papers in selected countries, 1976, 1981, 1986

Note: The figure represents the value of 1976 as the starting point, that of 1981 as the intermediate point and that of 1986 as the final point.
Source: NISTEP " Japanese S&T Indicator System"
Citation: Computer Horizons, Inc., "Science & Engineering Literature Data Base, 1989"

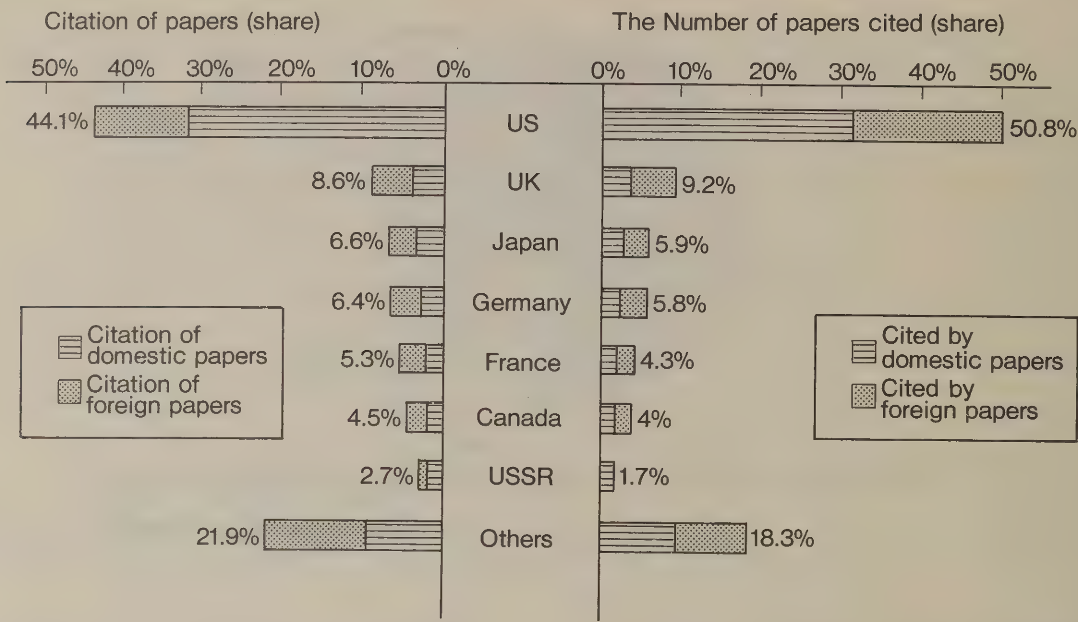


Figure 1-1-16. Shares of papers citing and being cited by other papers

Note: The figures for shares are averages of 1984 to 1986 data.
Source: NISTEP:"Japanese S&T Indicator System"
Citation: Computer Horizons, Inc., "Science & Engineering Literature Data Base, 1989."

that Japanese papers' impact on researchers of other countries is not so high.

In 1981, 80 percent of the papers cited by Japanese researchers were written by Japanese researchers, but this percentage dropped to about 40% in 1986, showing a drastic increase of citations of foreign papers in a short period of time.

Taking the total frequency of citations in the world as 100%, 37.0% of the total citation was done within the US/Canada, followed by 13.8% within the EC countries. Among regions, citations of EC papers in US/Canada accounted for 10.0%, and citations of American/Canadian papers in the EC was 7.1%, showing frequent citations between these two regions. Because of differences in geographical condition and language, the percentage of citations of Japanese papers from abroad is low (Figure 1-1-17).

Among 900 papers which were cited most frequently in the period from 1988 and 1990, 42 papers (4.7% of the total) were written by Japanese researchers, a smaller percentage than the share of all the cited papers. This shows that the impact of Japanese papers in the most advanced research activities is still small. Among these 42 papers, those in the life sciences numbered 25, showing active research in this field. Among the 10 most frequently cited papers from September to October in 1989, those in first and third places in physics, and those in second and third places in biology were written by Japanese researchers working at Japanese research institutes. Among the top 10 papers most frequently cited in the 1980s, two were written by Japanese researchers. This shows the existence of excellent papers written by Japanese researchers.

(3) Internationally Co-authored Papers

The number of the papers written jointly by researchers of different countries has been increasing. While the ratio of international co-authorship in Japan is increasing, fewer

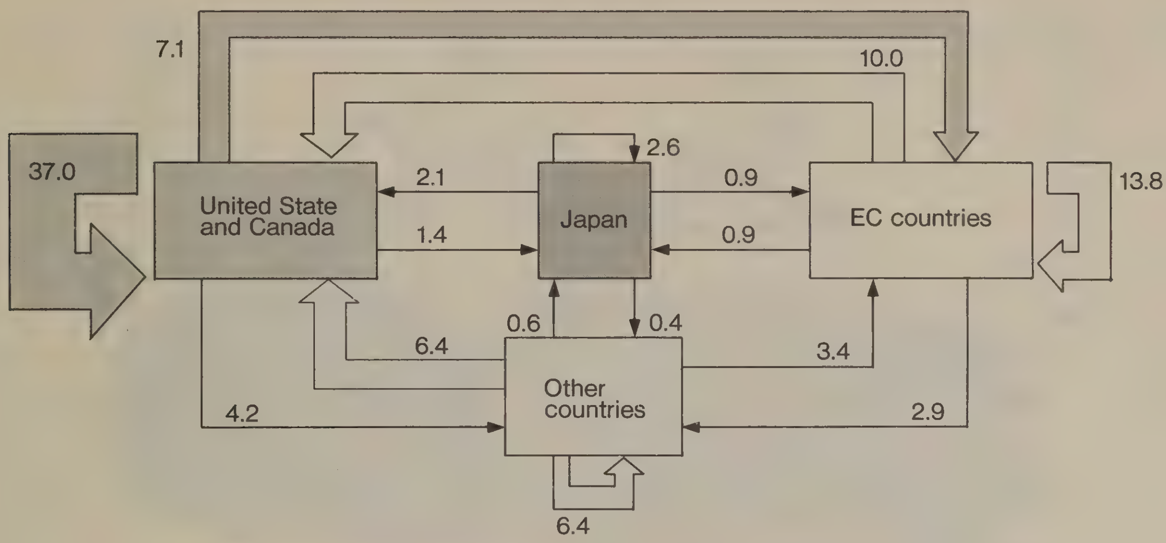


Figure 1-1-17. Citation shares in the world

Notes: 1. Papers cited in 1984-88 are covered.
2. Figure shows percentage of each country's papers of worldwide citations.
Source: Science Citation Index (ISI Inc. USA)

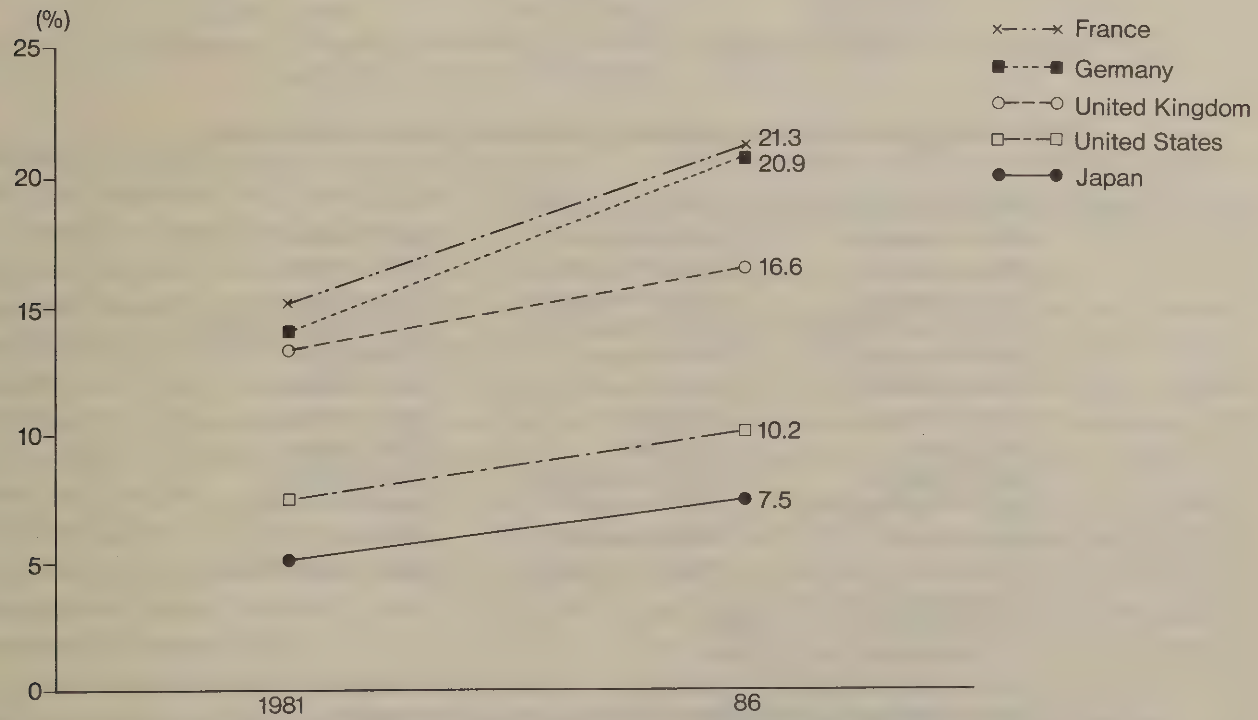


Figure 1-1-18. Trends in internationally co-authored papers by country

Compilation: Science and Technology Agency
Source: Computer Horizons, Inc., "Science & Engineering Literature Data Base 1989"

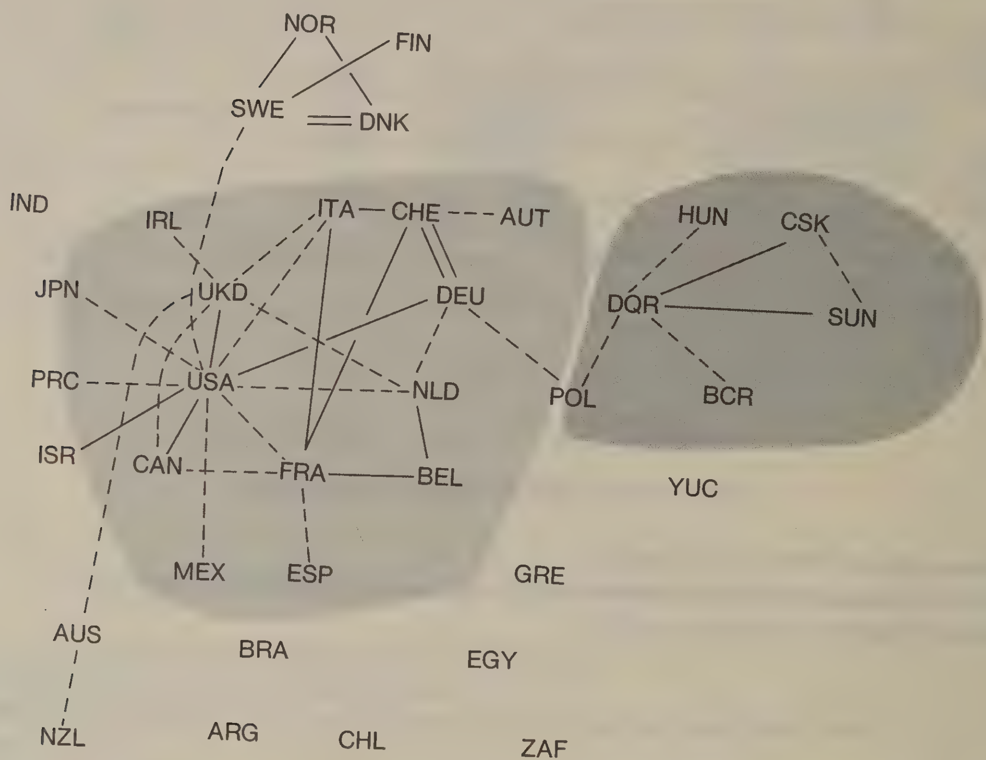


Figure 1-1-19. World map of international cooperative links in the sciences

Notes: 1) The country abbreviations used are as follows:

ARG = Argentina	AUS = Australia	AUT = Austria
BEL = Belgium	BGR = Bulgaria	BRA = Brazil
CAN = Canada	CHE = Switzerland	CHL = Chile
CSK = Czechoslovakia	DEU = Germany FR	DDR = Germany DR
DNK = Denmark	EGP = Egypt	ESP = Spain
FIN = Finland	FRA = France	GRC = Greece
HUN = Hungary	IND = India	IRL = Ireland
ISR = Israel	ITA = Italy	JPN = Japan
MEX = Mexico	NLD = Netherlands	NOR = Norway
NZL = New Zealand	POL = Poland	PRC = PR China
SUN = USSR	SWE = Sweden	UKD = UK
USA = USA	YUG = Yugoslavia	ZAF = South Africa

2) ══ shows 2.5% $< r_{ik}$
—— shows 1.5 $< r_{ik} < 2.5\%$
------ shows 1.0 $< r_{ik} < 1.5\%$
The relative strength r_{ik} is given by $r_{ik} = n_{ik} / (n_i \cdot n_k)^{1/2}$ where n_i and n_k is the total number of papers published by countriesi and K, respectively

Source: Scientometrics, Vol. 19, No. 1-2, 1990 International Collaboration in the Sciences, 1981-85, by A. Schubert, T. Braun

Citation: ISI Inc., Data Base

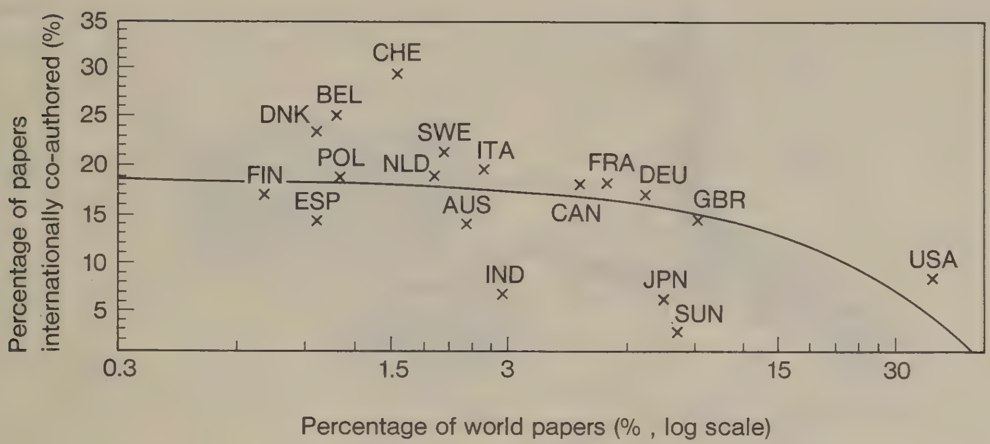


Figure 1-1-20. Comparison between internationally co-authored papers and number of papers 1981-86

Note: The country abbreviations used are as follows:

AUS=Australia	BEL=Belgium	CAN=Canada
CHE=Switzerland	DEU=Germany FR	DNK=Denmark
ESP=Spain	FIN=Finland	FRA=France
GBR=Great Britain	IND=India	ITA=Italy
JPN=Japan	NLD=Netherlands	POL=Poland
SUN=USSR	SWE=Sweden	USA=USA

Source: An Outline for Understanding Patterns of International Scientific Collaboration by T. Luukkonen, O. Persson, G. Sivertsen

Japanese are participating than are researchers of other developed countries (Figure 1-1-18).

American researchers are the world's most popular partners in internationally co-authored papers (Figure 1-1-19). This is at least in part due to the fact that US researchers publicize the most papers and also are cited most frequently. Relatively large numbers of co-authored papers are written in Scandinavia and Eastern Europe; this may reflect geographical, political, and cultural factors of these countries proximity which encourage close communication. Japanese co-authored papers exist to some extent with American counterparts.

As for the ratio of co-authorship and number of papers published in each country, it is almost at the same level among European countries, regardless of the total number of publicized papers. This ratio is low in Japan, the USSR and India, probably because specific characteristics of these countries differ from those of Europe, in terms of geographical conditions, language and social institutions. The percentage of internationally co-authored papers in the US is also small compared with that of European countries. This is probably attributable to geographical differences and the large number of papers written in the US. -- Furthermore, US authors can find co-authors easily within the country (Figure 1-1-20). For Japanese researchers to have more chances of co-authorship with their counterparts overseas, it is essential to encourage their participation in international networks of researchers, as mentioned above.

1.1.2.1.2.3. Dissemination of Information

An analysis of the usage of the Scientific and Technical Information Network (STN), which is offered by the Japan Information Center of Science and Technology (JICST), the Chemical

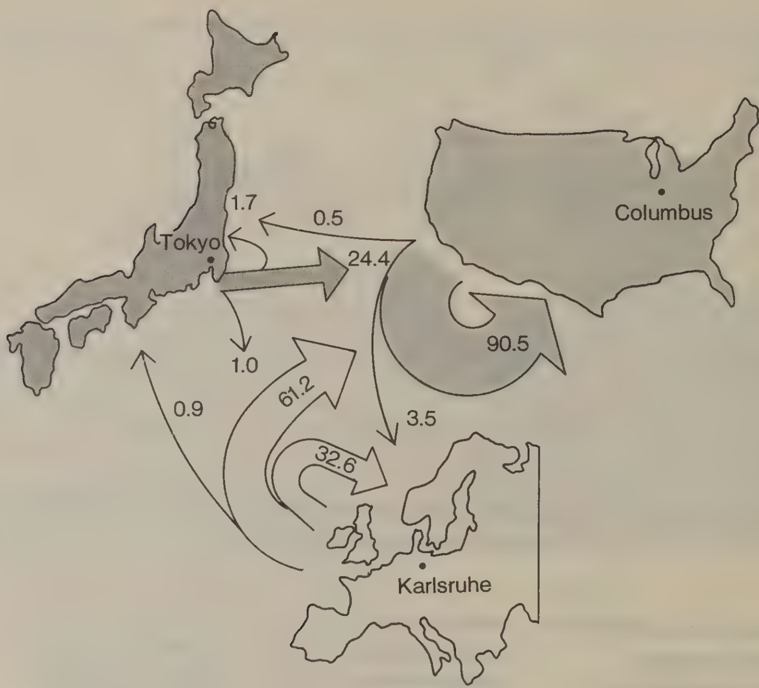


Figure 1-1-21. Usage of databases on the scientific and technical information network (STN) by connected hours

Notes: 'A→B' means 'access from A to B' Figure shows connected hours during 1989(thousand hrs.). The related organization in each country is as follows:
Japan: Japan Information Center of Science and Technology (JICST) in Tokyo
U.S.A.: Chemical Abstracts Service (CAS) in Columbus, Ohio
Germany: Fachinformationszentrum-Karlsruhe (FIZ-Karlsruhe) in Karlsruhe
Source: Japan Information Center of Science and Technology

Abstracts Service of the United States, and the Karlsruhe Specialized Information Center of Germany, shows that the number of accesses to the US database is the largest. Although European countries access the US database over 60% of the time, Japan accesses the US database during about 90% of its connected hours. There is currently little access between Japanese and European databases (Figure 1-1-21). The connected hours to JICST's English database has been increasing recently, but the amount of data sent from Japan overseas is still very small compared with the overseas data received by Japan. To increase the international dissemination of Japanese S&T information, The Ministry of Education's National Center for Science Information System has begun providing data to overseas researchers through the information system of the US National Science Foundation, the US Library of Congress in Washington, and the British Library in London.

1.1.2.1.2.4. Patents

(1) Patent Application and Registration

The number of patent applications by Japanese people is the largest in the world, and the number of registered patents is the second largest, following the US. The number of applications submitted to the Japanese Patent Agency increased sharply in the 1980s in particular, but the number of registrations has not increased in

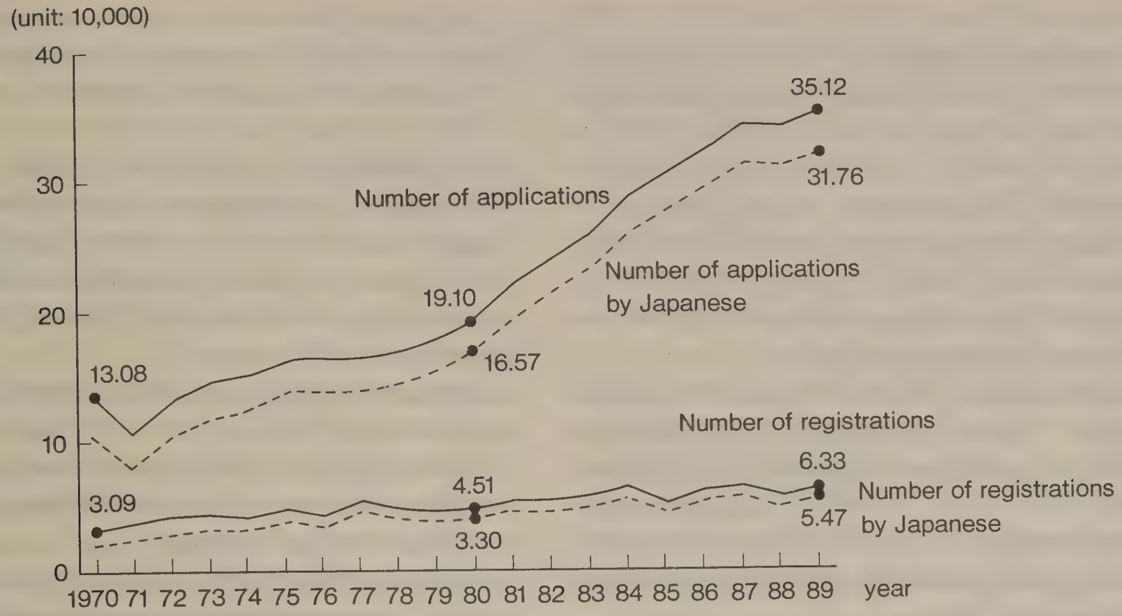


Figure 1-1-22. Patent applications/registrations in Japan

Source: NISTEP: "Japanese S&T Indicator System"
Citation: Patent Agency: "Patent Agency Yearbook, 1989"

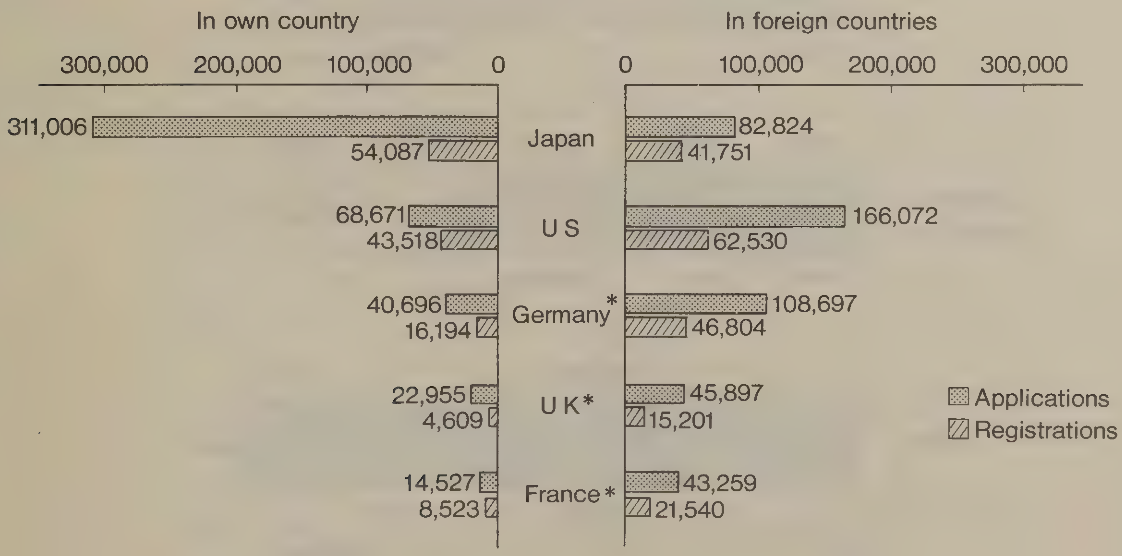


Figure 1-1-23. Patent applications/registrations in selected countries, 1987

Note: * indicate EPC (European Patent Convention) member countries.
For EPC patent applications/registrations, each designated country is counted as one.
Source: NISTEP "Japanese S&T Indicator System"
Citation: Patent Agency "Patent Agency Yearbook, 1989"

proportion (Figure 1-1-22). From 1980 to 1989, the number of Japanese researchers in private companies increased by 75%, and the number of patent applications increased by 92%, indicating that the number of applications per researcher increased. The number of applications by foreigners has remained at about the same level during these years, so the percentage of foreigners' applications to the total applications has been decreasing gradually.

In the field of biotechnology, however, the number of patent applications by foreigners is almost as many as the number by Japanese researchers. It is expected that innovative breakthroughs in biotechnology which will impact greatly on society will be reflected in new patents in the future.

(2) Patent Application and Registration Inside and Outside Japan

In Japan, the number of applications to the patent authority is extremely large, compared with applications in other developed countries to their own patent authorities, but the number of registrations is very small (Figure 1-1-23). While Japan's total number of applications is the largest in the world, the number of applications by Japanese to patent authorities outside the country is the third largest, following those by Americans and Germans.

Japanese applicants submit overseas patent applications mostly to the US, followed by Germany, the UK, France, and Korea. Japanese are filing more applications to the Korean patent authority than are Koreans.

Patent registrations consist mostly of a country's own applicants in major countries, but the percentage of Japanese in Japan accounts for nearly 90% (Figure 1-1-24). The percentage of patents registered by Japanese in the US has been

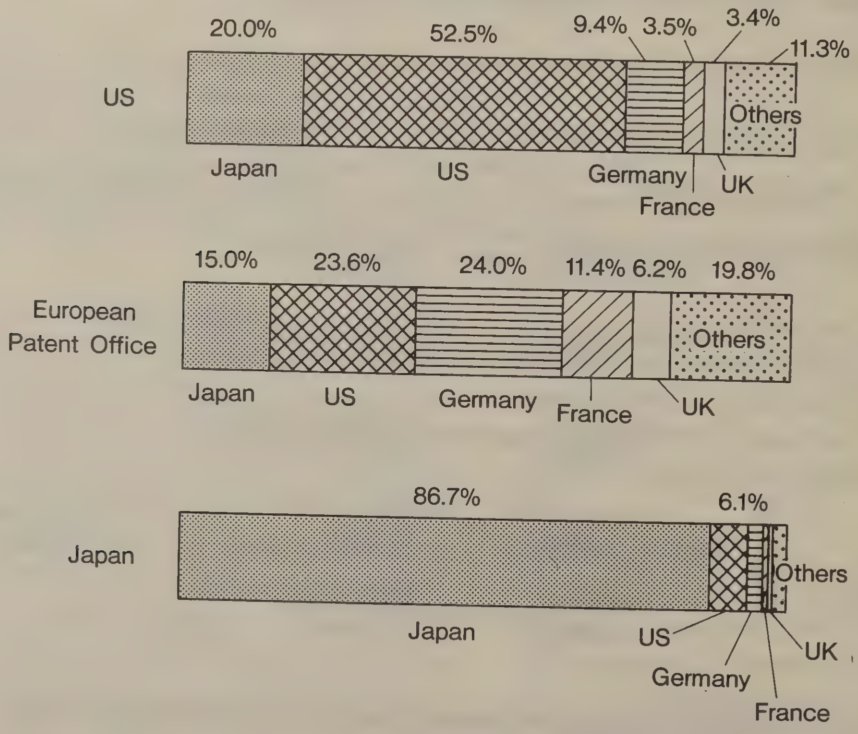


Figure 1-1-24. Patent registration by countries at selected patent authorities

Source: NISTEP: "Japanese S&T Indicator System"
Citation: Patent Agency: "Patent Agency Yearbook, 1989"

increasing year by year. In 1990, five Japanese companies were among the top ten companies registering the largest number of patents in the US.

The number of citations of a registered patent (the number of times a registered patent is cited during examination of a subsequent patent application) indicates the importance of that patent. Figure 1-1-25 indicates the share of cited patents and share of patent registrations in the US. Both percentages are largest for US-authored patents, but the US relative citation ratio (percentage of citations divided by percentage of patent registrations) has been decreasing. On the other hand, Japan's relative citation ratio has been rising, indicating that Japanese-authored patents are increasing in importance.

Compared with the number of Japanese patent applications and registrations to foreign authorities, those by non-Japanese to the Japanese patent authority are much fewer.

1.1.2.1.2.5. Trade in Technology and in High-Technology Products

(1) Technology Trade

Technology trade within the OECD (in the forms of transfer of rights, patent license, etc.) has been increasing among all the member countries and regions (Figure 1-1-26). Only in the US case technology exports exceed imports and other countries' technology imports exceed exports. Japan's technology trade balance (export/import) is improving gradually (refer to Appendix 11).

Among selected countries, the US has a significant technology trade surplus. Japan has a technology trade surplus only with the UK (Table 1-1-27).

Analyzing technology trade by region, Japan has a deficit in relation to North America and Europe, and a surplus with Asian and Oceania

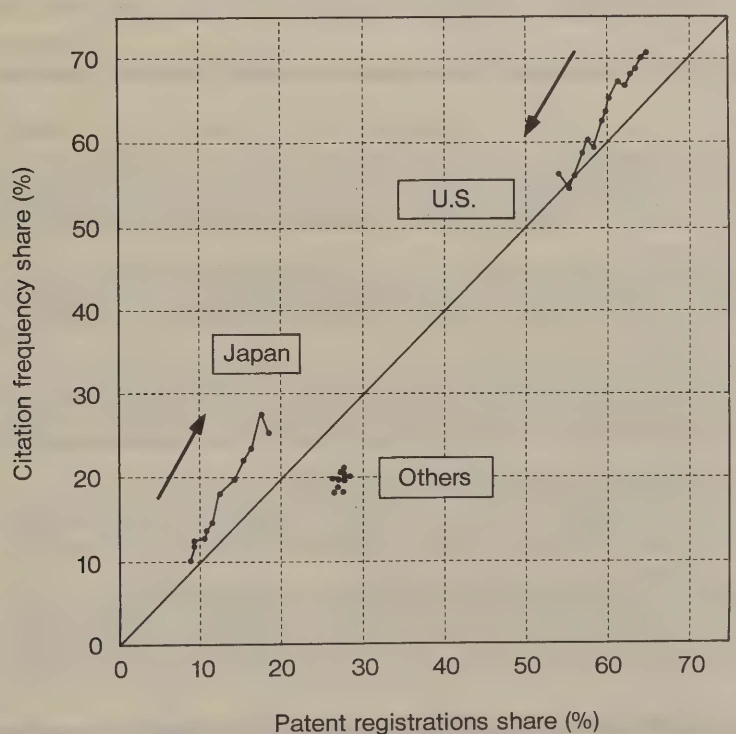


Figure 1-1-25. Changes in relative frequency of citation of registered patents in the US, 1975-1986

Source: NISTEP: "Japanese S&T Indicator System"
Citation: Computer Horizons, Inc., "Science & Engineering Literature Data Base, 1989"

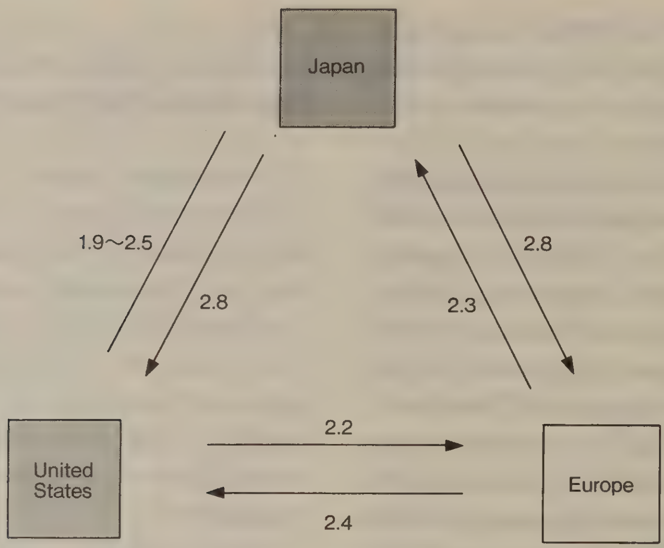


Figure 1-1-26. Expansion of trade in technology among Japan, US and Europe

Note: Figures shown are the ratios of value of exports in technology trade in 1989 to those in 1984 (dollar based comparison).
Source: Management and Coordination Agency, the Statistics Bureau: "Report on the Survey of Research and Development"
US Department of Commerce: "Survey of Current Business"

Table 1-1-27. Technology Trade Balance among Selected Countries

Trade partner / Country (Year)	Japan	US	Germany	France	UK
Japan (1989)		0.51	0.56	0.23	1.84
US (1990)	5.36		4.31	6.89	2.82
Germany (1990)	1.36	0.32		0.85	0.57
France (1989)	-	0.20	0.98		2.08
UK (1988)	-	0.53	-	-	

Notes: 1. Reading across, each figure indicates the technology trade balance (exports/imports) of the country with its trade partners. Thus Japan, in 1989, exported considerably more technology to the UK than it imported from the UK.
2.US as trade partner of France and UK includes Canada.
Source: Statistics of each country compiled by Science and Technology Agency.

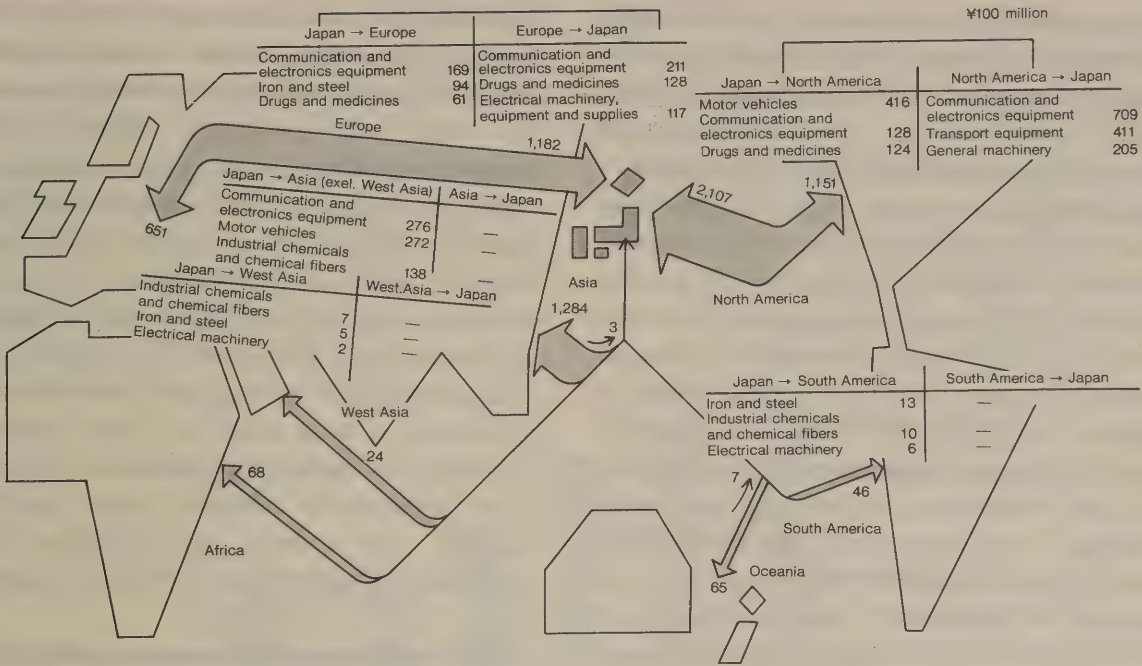


Figure 1-1-28. Japan's technology trade with world (FY1989)

Compilation: Science and Technology Agency
Source: Management and Coordination Agency, the Statistics Bureau: "Report on the Survey of Research and Development"

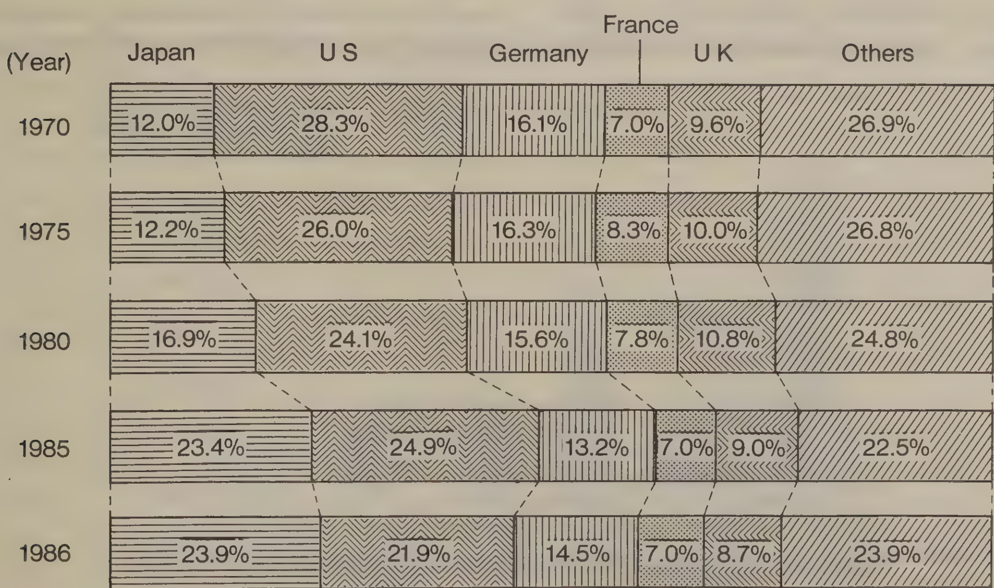


Figure 1-1-29. Export of high-tech products by selected countries

Note: High-tech products: aerospace, office computers, electronics & components, drugs, electrical machinery.
Source: US National Science Board "Science & Engineering Indicators (1989)"

countries. Analysis by industry types illustrates characteristics of each country/region's technological strength. In order of amounts, Japan exports motor vehicles, communication and electronics equipment and drugs & medicines to North America. In reverse, Japan imports from North America communication and electronics equipment, transport equipment, and general machinery. To Europe, Japan exports communication and electronics equipment mostly, followed by iron and steel, and drugs & medicines. Japan imports from Europe mostly communication and electronics equipment, then drugs and medicines and electric machinery technology (equipment and supplies). While Japan exports advanced technology such as electronics to developed countries, steel and chemical/textile technology is an important portion of its export to developing countries (Figure 1-1-28).

(2) Trade in High-Tech Products

The value of the worlds' high-tech product trade has been increasing. Japan is the world's largest exporter of such products, reflecting its high level of manufacturing technology. While Japan's percentage of the world's exports of high-tech products has been rising, that of the US has been declining (Figure 1-1-29). Comparing trade balances of major countries for high-tech products in 1987, Japan had the largest trade surplus, 5.1 times imports in value among selected countries. While Germany had a slight trade surplus, high-tech trade is almost balanced in France, the UK and the US. (Figure 1-1-30). The growing ratio of high-tech products trade as a portion of total trade can cause increasing international exchange of technology. However, it is necessary to carefully watch this trend because such flows of technology could eventually create tensions between countries.

1.1.2.2. International Exchange within Governmental Policy Enforcement

1.1.2.2.1. International Exchange of Researchers

Japanese researchers dispatched overseas from national research institutes almost doubled during the period FY1984 to FY1989, from 1,156

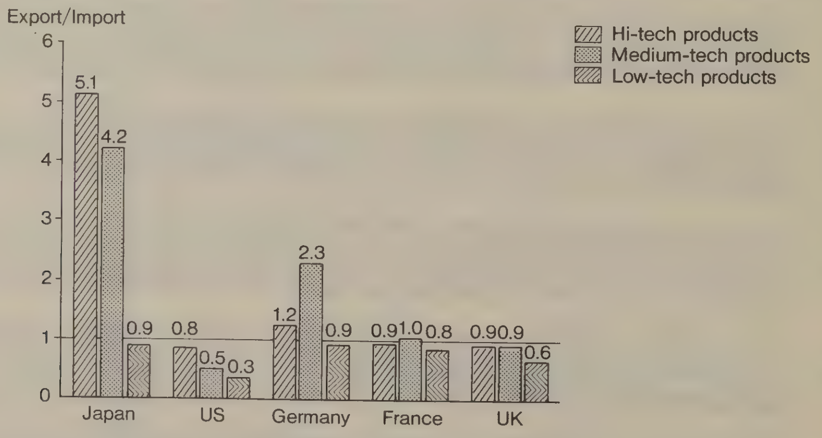


Figure 1-1-30. Products trade balance by technological intensity

Note: The OECD categorizes products as follows. "Hi-tech products" : aerospace, office machines, computers, electronics & components, drugs and electric machinery.
"Medium-tech products": automobiles, chemical, other non-electrical machinery, rubber, plastic, non-ferrous metals, other transport machineries.
"Low-tech" :others.
Source: OECD Statistics

to 2,303. In the same period, foreign researchers visiting Japanese national research institutes increased from 217 to 622, almost 2.9 times (Figure 1-1-31).

The ratio of outgoing to incoming researchers, was 5.3 in FY1984 but dropped to 3.7 in FY1989. This was a considerable improvement and reflected the results of efforts to accept more foreign researchers to national research institutes.

Researchers from academic institutions who were dispatched overseas through programs

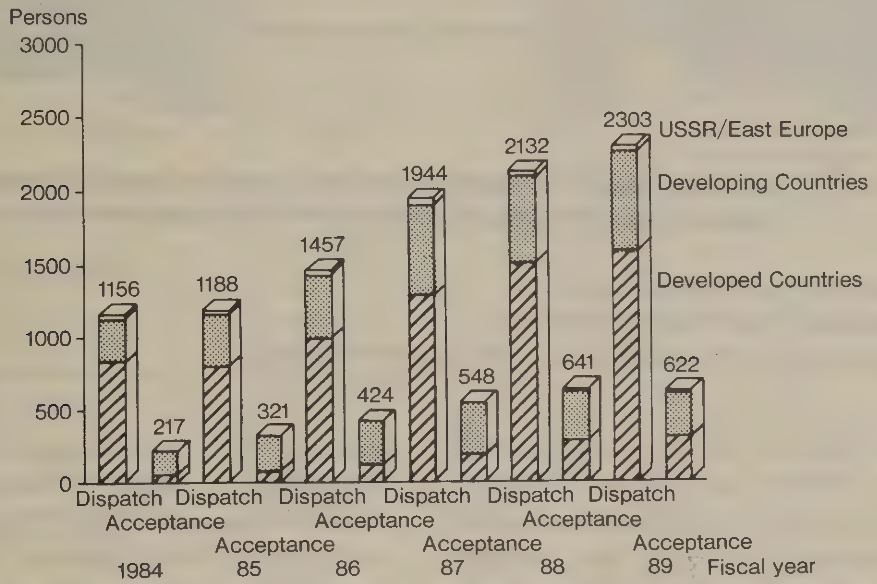


Figure 1-1-31. Exchange of researchers at national research institutes

Source: Science and Technology Agency

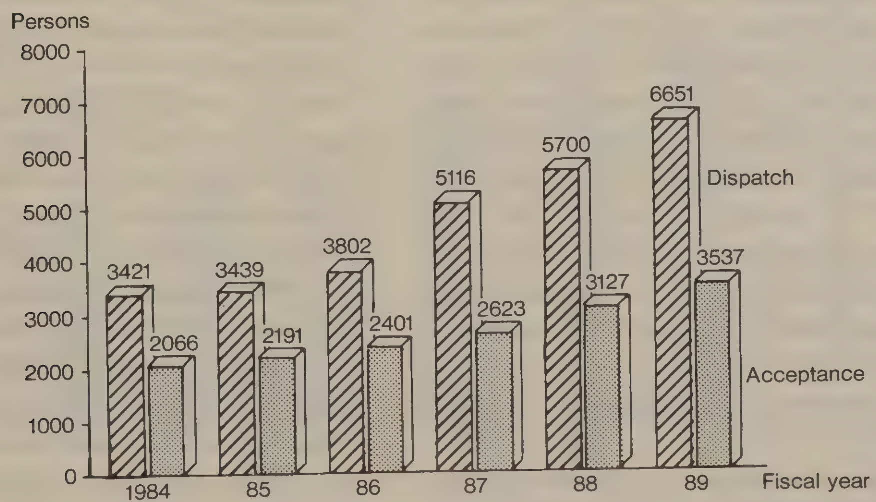


Figure 1-1-32. Exchange of researchers by programs supported by the Ministry of Education

Source: Ministry of Education

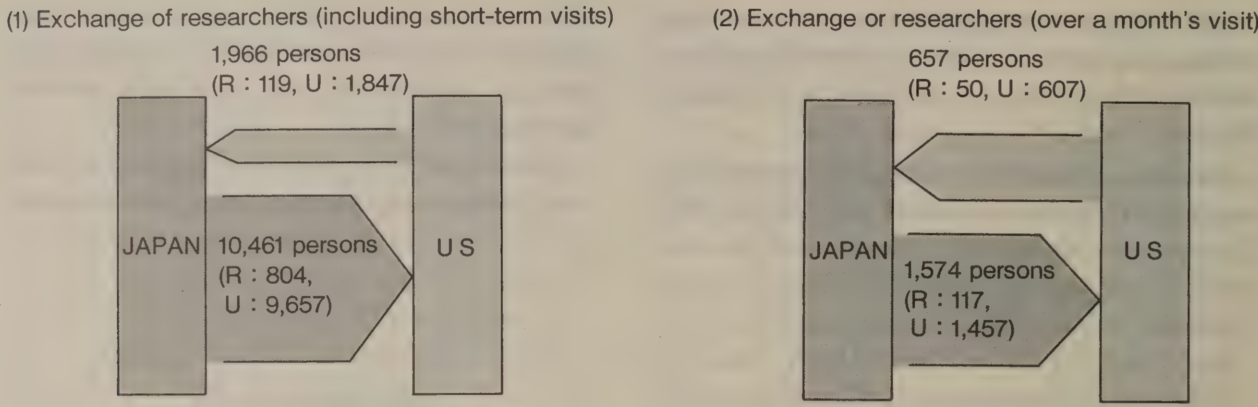


Figure 1-1-33. Exchange of researchers between Japan and the US at Japanese national research institutes and national universities/colleges

Note: R = National Research Institutes
U = National Universities and Colleges
Source: Science and Technology Agency, Ministry of Education

related to the Ministry of Education increased from 3,421 in FY1984 to 6,651 in FY1989, an increase of 1.9 times. During the same period, foreign researchers accepted by academic institutions increased 1.7 times, from 2,066 to 3,537 (Figure 1-1-32).

As these figures indicate, international exchange of researchers has been expanding steadily. The number of foreign researchers coming into Japan has been increasing considerably in recent years, but at the same time, the number of Japanese researchers visiting other countries is rapidly increasing, resulting in the number of outbound researchers still exceeding the number coming in. The destinations of Japanese researchers are mostly developed countries, the US in particular. Many come to Japan from China and other developing countries, but the number of researchers from developed countries also has been increasing these years.

While a large number of Japanese researchers visit overseas, many of them stay only for a short term, for instance to attend academic meetings and conferences. It thus would be useful to consider the number of researchers who stayed overseas for a prolonged length of time. Regarding the Japan -US researcher exchange based on Japanese public research institutions, in FY1989 1,966 American researchers were received by Japanese national universities (1,847) and national research institutes (119), and 10,461 Japanese researchers (9,657 from national universities, 804 from national research institutes) were dispatched overseas. This resulted in an outgoing-incoming ratio of 5.3 (5.2 at national universities and 6.8 at national research institutes). Taking into account only stay longer than a month, there were 657 American (607 at national universities and 50 at national research institutes) and 1,574 Japanese researchers (1,457 from national universities and 117 from national research institutes), making that ratio 2.4 (2.4 at national universities and 2.3 at national research institutes). This ratio is a much more balanced one in comparison with the ratio of 13.2 between outgoing and incoming researchers according to the emigration and immigration statistics. It is more indicative of Japan's efforts to provide increasing opportunities for research in Japan (Figure 1-1- 33).

In recent years, the government has placed

increasing importance on enhancing international exchange, especially on increasing invitations to foreign researchers. The Science and Technology Agency, the Ministry of Education, and MITI initiated their respective fellowship programs in FY1988 (Figure 1-1-34).

Also, in FY1990, the Summer Institute Program was launched to provide American graduate students in natural sciences with the chance of a two-month stay in Japanese national research institutes to conduct research with Japanese scientists. In FY1990, 25 Americans participated in the program. In FY1991, the participants numbered 49, several of whom were

Table 1-1-34. Outline of major fellowship programs

Name of fellowship	Field	Period	Number of awardees (FY1991 budget)
Science and Technology Agency Fellowship program	Science and Technology	6 months-2 years	180
Japan Society for the Promotion of Science Postdoctoral Fellowship for Foreign Researchers	Natural sciences, Social sciences, and humanities	1 year	175
Agency of Industrial Science and Technology International Research Exchange Program	Natural sciences (industrial technology)	1 year	14

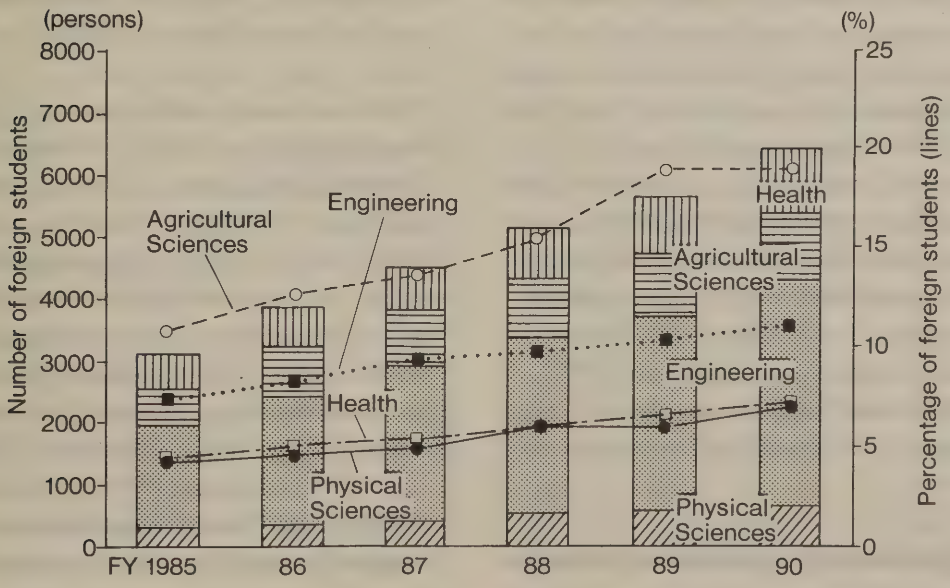


Figure 1-1-35. Number of foreign students at graduate schools (physical sciences, engineering, agricultural sciences, health)

Source: Ministry of Education

accepted by private research institutes.

The total number of foreign students studying at Japanese public and private graduate schools (in the fields of physical sciences, engineering, agricultural sciences, health) increased from 3,111 in FY1985 to 6,470 in FY1990, a 2.1-fold growth in five years. Agricultural sciences had the greatest growth in ratio of foreign students, from 10.7% in FY1985 to 18.9% in FY1990. In the field of engineering, the ratio of foreign students reached 11.1% in FY1990 (Figure 1-1-35).

(1) Law for Facilitating Governmental Research Exchange

In order to promote exchanges of researchers in national research institutes with their counterparts in Japanese private, academic, and public research organizations and overseas, the Law for Facilitating Governmental Research Exchange was enacted in May 1986. This enabled assignment of foreign researchers as government researchers at positions as high as research division manager or research section managers. This law also encourages participation in research meetings, and enables free or low-cost use of intellectual property right patents and waiver of compensation claims resulting from international joint research activities.

As of July 1991, nine foreign researchers have been assigned as government researchers under the provision of this law. This law also authorized government researchers temporary exemption from their duties in order to participate in research conferences. As of 1 January 1991, a total of 11,568 researchers got permission under this provision (2,867 researchers overseas and 8,701 domestic).

1.1.2.2.2. International Collaborative Research

1.1.2.2.2.1. International Collaborative Research Programs Proposed by Japan

(1) Human Frontier Science Program

At the Venice Economic Summit in 1987, Japan proposed the Human Frontier Science Program (HFSP) which promotes basic research on elucidating the sophisticated and complex mechanisms of living organisms. The International HFSP Organization (HFSPO) was established in France in 1989 as the program's operating body.

The program includes: research grants (grants for basic research carried out by international joint research teams); fellowships (fellowships for researchers who wish to do research in foreign countries); and workshops (subsidies for international workshops). According to the March 1991 announcement of the HFSPO on recipients of second year (FY1990) grants, research grants were provided to 139 people for 32 themes, and long term fellowships were awarded to 90 people. Among Japanese, US, and European researchers who received long-term fellowship, 32 European researchers wished to do research in the US or Canada, and 20 Japanese also wished to work in the US or Canada followed by thirteen US/Canadian researchers wishing to go to Europe. Only two Europeans wished to work in Japan (Figure 1-1-36).

(2) International Joint Research by the Research Development Corporation of Japan

International joint research conducted by government research institutes, academia, and industry with overseas research organizations is expected to produce high level results which can not be achieved by single institute. Such efforts thus should be very useful for both Japan and other participating countries. International joint research by the Research Development Corporation of Japan (JRDC) combines Japanese strength with that of other countries to pursue integrated research activities toward the creation of innovative science and technology. Publications resulting from successful achievement will contribute to the world, promoting more vigorous international exchange, and boosting further advancement of science and

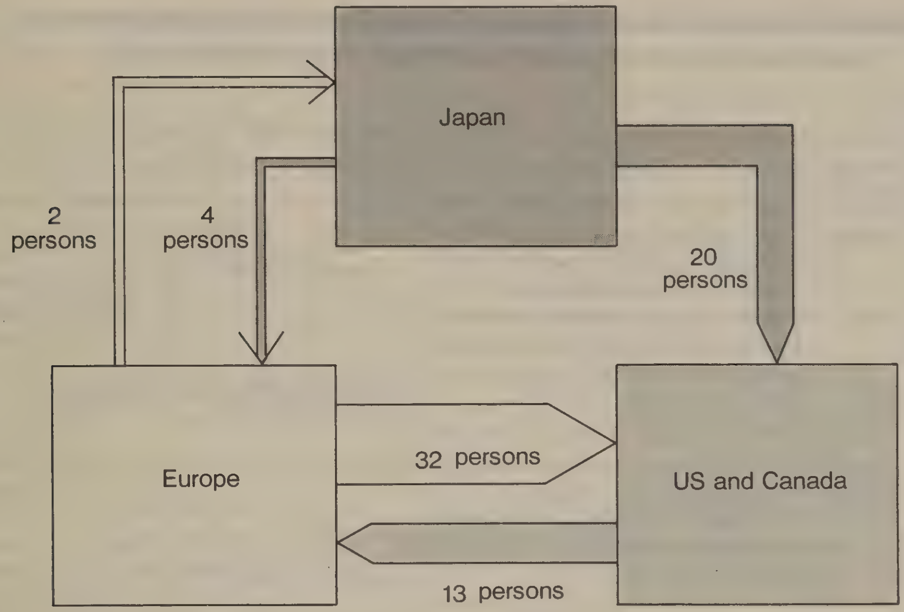


Figure 1-1-36. Flow of awardees (HFSP Long-term Fellowship)

Note: Excluding areas other than Japan, Europe and US/Canada Figures are those of FY1990
Source: International HFSP Organization

technology.

(3) Intelligent Manufacturing System (IMS)

The IMS project aims to develop a high level, next generation, manufacturing system which will flexibly integrate and operate the whole of corporate activities -- from order placing to design, manufacturing, and distribution -- by interfacing man and intelligent machines, leading to increased productivity. This system will be developed through collaborative efforts by researchers in various developed countries such as in the US, Europe, and Japan. In FY1991, leading researchers from various countries will conduct feasibility studies related to the project.

1.1.2.2.2.2. International Joint Research at National Research Institutes and Academic Institutions

The Special Coordination Fund for Promoting Science and Technology was initiated in FY1981 as a financial resource to implement important research activities necessary for science and technology promotion & coordination. This fund is operated according to the policy set forth by the Prime Minister's Council for Science and Technology, the supreme advisory body on science and technology policy in Japan. Through this fund, international joint research activities (in the forms of Comprehensive Joint Research, Basic Research Core System, Bilateral International Joint Research, etc.) have been conducted mainly at national research institutes. Utilizing this fund, the International Workshop Support Program (STA Workshop) which started in FY1991 supports workshops where Japanese and foreign researchers can directly communicate with each other in specific fields (Figure 1-1-37).

Ministries and Agencies also have their own international joint research programs. The Ministry of Health and Welfare has been involved in joint research with the US on the spreading of diseases in Asia; the Ministry of Agriculture, Forestry, and Fishery's Tropical Agriculture Research Center has been studying

Table 1-1-37. International exchange of research activities through special coordination funds for promoting science and technology (SCF).

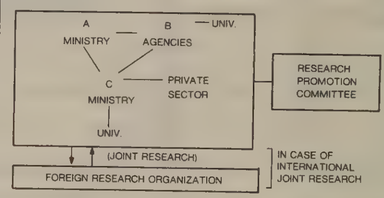
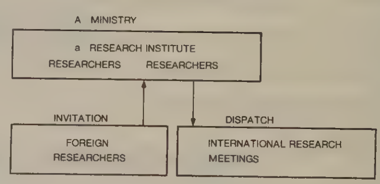
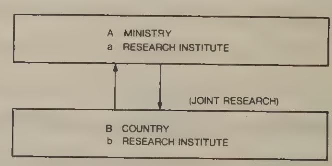
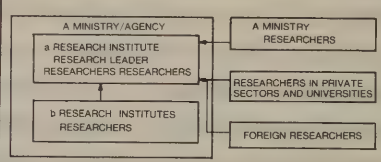
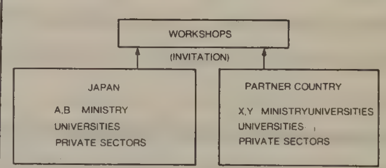
Name of program	Year of initiation	Outline	Activity pattern	Number of projects
Comprehensive Joint Research	FY1981	This research system exists through organic ties among industries, the government and academia, and is weighted in favor of the basic and advanced science and technology fields.		33 (incl. 9 international joint research projects)
Encouragement of Basic Research	FY1985	This system creates seeds for innovative technologies at national research institutes		206 (incl ---46 for inviting foreign researchers, and 94 for dispatching researchers to international research meetings)
Bilateral International Joint Research	FY1987	This system promotes research cooperation on the basis of international commitments on government level.		80
Basic Research Core System	FY1988	This system promotes fundamental research in national research institutes by gathering researchers inter-ministerially and internationally to one national research institute and enabling researchers to give full scope to their trailblazing studies.		24
International Workshop Support Program (STA Workshop)	FY1991	This program was established to finance international workshops, where researchers and government officers exchange views on mutual needs and research trends and discuss ways of cooperation, thus promoting international research exchange.		

Table 1-1-38. Major international joint research projects at academic institutions

Scheme	Outline
International joint research based on an intergovernmental cooperation agreement	Participation by US team in the Tristan Experiment Project of the National Laboratory for High Energy Physics, joint experiments at CERN, participation in ODP (Ocean Drilling Program) for the purpose of elucidating the sea bottom crust structure using the JOIDES Resolution, participation by UK & US in x-ray astronomic observations using the scientific satellite "Ginga" of the Institute of Space and Astronautical Science.
International joint research supported by the International Council of Scientific Unions	Promotes international research activities on a global scale, such as earth science projects, which need collection and analysis of data on a large scale. Examples are observation of the antarctic region, WCRP (World Climate Research Program) and IGBP (International Geosphere-Biosphere Program).
International joint research through UNESCO	Multinational programs are being implemented in marine science, environment science and other areas in an effort to elucidate various problems common to mankind. Examples are IOC (International Oceanographic Commission) and MAB (International Coordinating Council of the program on Man and the Biosphere).
International joint research through the Research Grant Program "International Scientific Research."	Scientific investigations, joint research, inter-university collaborative research, and special studies on cancer fall under this category.
International joint research through the Japan Society for the Promotion of Science (JSPS)	Besides assisting international joint research programs, JSPS implements bilateral programs such as Japan-US scientific cooperation activities. With ASEAN countries, key universities are set both in the partner country and in Japan for each project, and exchanges are implemented between these centers. There are also large-scale collaborative research projects.

the agricultural and livestock industry in tropical and sub-tropical regions. MITI's Institute for Transfer of Industrial Technology (ITIT) focuses on mining engineering technology transfer with developing countries. An analysis of the movement of the earth's crustal plate via the VLBI observation system has been conducted at the Ministry of Posts and Telecommunications' Communications Research Laboratory (CRL).

At Academic institutes, international joint research programs have been conducted actively through bilateral cooperation agreements between governments, programs of the ICSU and UNESCO, Grants-in-Aid for Scientific Research (International Scientific Research) of the Ministry of Education, and programs of the Japan Society for the Promotion of Science (Table 1-1-38).

1.1.2.2.2.3. Participation by Foreign Researchers in Japan's Basic Research Programs

The Exploratory Research for Advanced Technology (ERATO) of the JRDC is a new "scientist-oriented" system with the goals of making the most of the advanced ideas coming from researchers in Japanese industry, academia, government, and from overseas participants; creating from basic research new ideas which would lead to new directions in science and technology in the future; and encouraging the growth of technological innovation. Foreign participants are well-represented in this system -- 76 researchers from 21 countries as of July 1991, accounting for 14% of the total participants.

The Frontier Research Program was initiated at RIKEN, the Institute of Physical and Chemical Research, in 1986 to invite researchers from a wide range of scientific fields under an internationally open and flexible system beyond the framework of traditional research systems in order to generate valuable scientific insights which will help form the basis of engineering innovation toward the 21st century. As of July 1991, research is conducted in four areas by 14 research teams which include 34 foreign researchers from 15 countries. These foreign researchers account for 16% of the total number of researchers.

The New Energy and Industrial Technology Development Organization provides funding for research activities by international research teams consisting of more than 4 researchers from more than two countries. From FY1988 to 1990, funds were provided to 18 research projects, involving a total of 93 researchers (including 50 foreign researchers from 7 countries).

1.1.2.2.2.4. Participation by Overseas Private Companies in Japanese R&D Projects

MITI's Research and Development Program on Basic Technologies for Future Industries takes up fundamental and innovative research themes in basic technology. These themes are essential to establish the next generation of industry. They require an early start on R&D, and high risks may be involved. Foreign companies are participating in projects such as "Non-linear Photonics Materials" and "Molecular Assemblies for a Functional Protein System".

MITI's National Research and Development Program (Large-Scale Project) provides funds for joint R&D by researchers in various sectors for innovative and advanced large industrial technology which is determined to be important

Table 1-1-39. Participation by countries in IEA's R&D cooperation Agreements

	Japan	US	Sweden	Canada	UK	Netherlands	Germany	Swizerland
Number of agreements for participation	24	33	27	25	20	20	18	17

Source: OECD, IEA, COMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT, "Progress in Energy R&D Collaboration and Policy issues: 1987 - 1990"

and urgently required for the national economy. Four overseas private companies are taking part of one of these projects, "Super/Hyper-sonic Transport Propulsion System". It is expected that more overseas private companies will participate in these kinds of Japanese R&D projects in the future.

1.1.2.2.3. Establishment of Overseas Research Facilities

One of the oldest Japanese overseas research facilities is the Showa Base in Antarctica, established in 1957. At this base, research activities, such as observing the aurora and conducting bionomic studies of marine life, have been conducted since then.

The National Astronomical Observatory of the Ministry of Education started in FY1991 the construction of a large infrared optical telescope in Hawaii.

Through the International Research Exchange Programs, JRDC launched an international joint research project on the "atom arrangement-design and control for new materials" in FY1989 at the University of Cambridge and the Imperial College of Science, Technology and Medicine, University of London. Another project on "microbial evolution" started in FY1990 at

Table 1-1-40. Financial and personnel contributions to international organizations

	UNESCO		WHO		IAEA		ITU	
	f.c. 1990-91	p.c. July 1990	f.c. 1990-91	p.c. Oct. 1990	f.c. 1990	p.c. Jan. 1990	f.c. 1991	p.c.
Japan	(1) 11.25%	(6) 21	(2) 11.17%	(6) 32	(3) 11.69%	(8) 20	7.1%	7
United States	--	(2) 48	(1) 25.00%	(1) 174	(1) 25.93%	(1) 104	7.1%	(3) 22
United Kingdom	--	(5) 26	4.77%	(2) 68	4.99%	(3) 44	7.1%	(4) 20
USSR	(2) 9.87%	(3) 37	(3) 9.80%	(4) 55	(2) 11.89%	(2) 59	7.1%	--
Germany	(3) 7.99%	(4) 30	(4) 9.19%	(5) 36	(4) 8.30%	(4) 40	7.1%	--
France	(4) 6.18%	(1) 53	(5) 6.13%	(2) 68	(5) 6.42%	(5) 37	7.1%	(1) 60
Italy	(5) 3.94%	16	3.91%	26	4.10%	--	--	--
India	--	10	--	32	--	--	--	(4) 20
Switzerland	1.07%	--	--	--	--	--	--	(2) 33

Note: 1. f.c.: financial contribution (budgetary contribution in percentage)
2. p.c.: personnel contribution (number of staff members)
3. o : ranking
Source: Science and Technology Agency

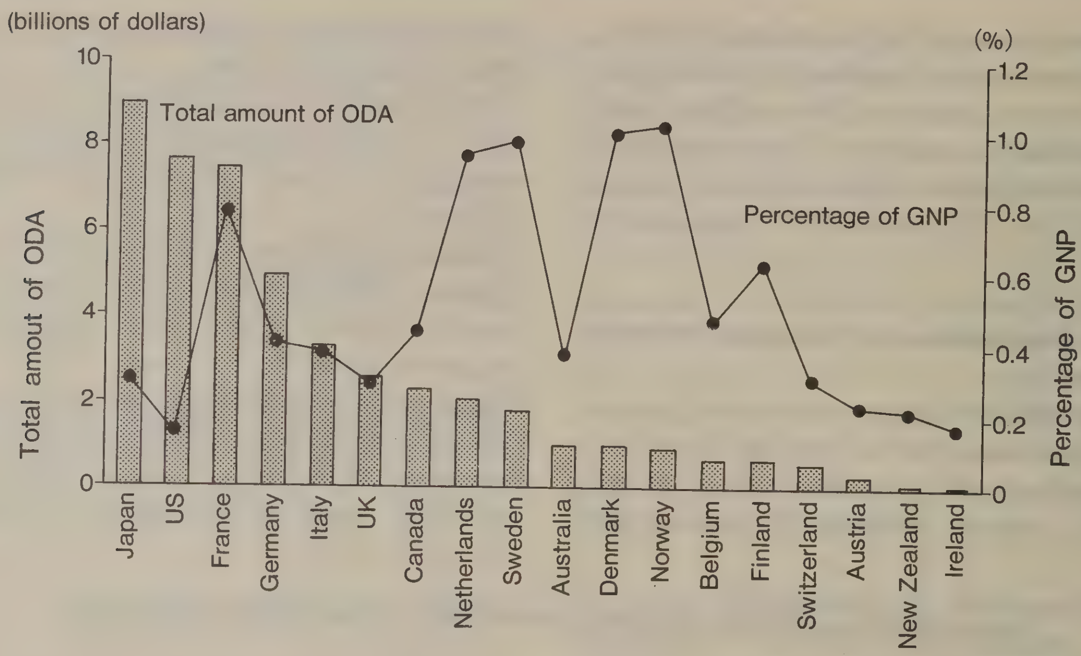


Figure 1-1-41. DAC countries' ODA (1989)

Note: Figure of France includes Department/Territories d'Outre-Mer
Source: Ministry of Foreign Affairs: "Japan's ODA"
Citation: DAC reports

Michigan State University in the US.

1.1.2.2.4. Cooperation with International Organizations

Japan has been one of the more active participants in international cooperation projects of the International Energy Agency (IEA), along with the US, Sweden, and Canada (Table 1-1-39). Although this reflects the importance of the energy issue for Japan, it shows Japan's positive attitude toward the development of energy technology through active international exchange.

While Japan's monetary contribution to international organizations is sizable (e.g., Japan is the largest contributor to UNESCO), its personnel contributions remain at a low level (Table 1-1-40). For example, Japan provides 12%, the third largest share, of funds to the IAEA, yet provides only about 3%, the 8th largest share, of personnel to that organization. One reason for this may be the language barrier, and another may be that the required period of assignment at these international organizations is longer than the normal assignment pattern within Japan. In order for Japan to expand its personnel contribution to international organizations, it is necessary to study further personnel administration and the treatment received upon return by those dispatched overseas.

1.1.2.2.5. Cooperation with Developing Countries through ODA

The Japanese government is committed to expanding its Official Development Assistance (ODA). The Cabinet approved in June 1988 the fourth set of medium-term ODA goals. These include increasing the percentage of ODA vis-a-vis GNP, expanding grants-in-aid toward the LLDCs, and encouraging technological

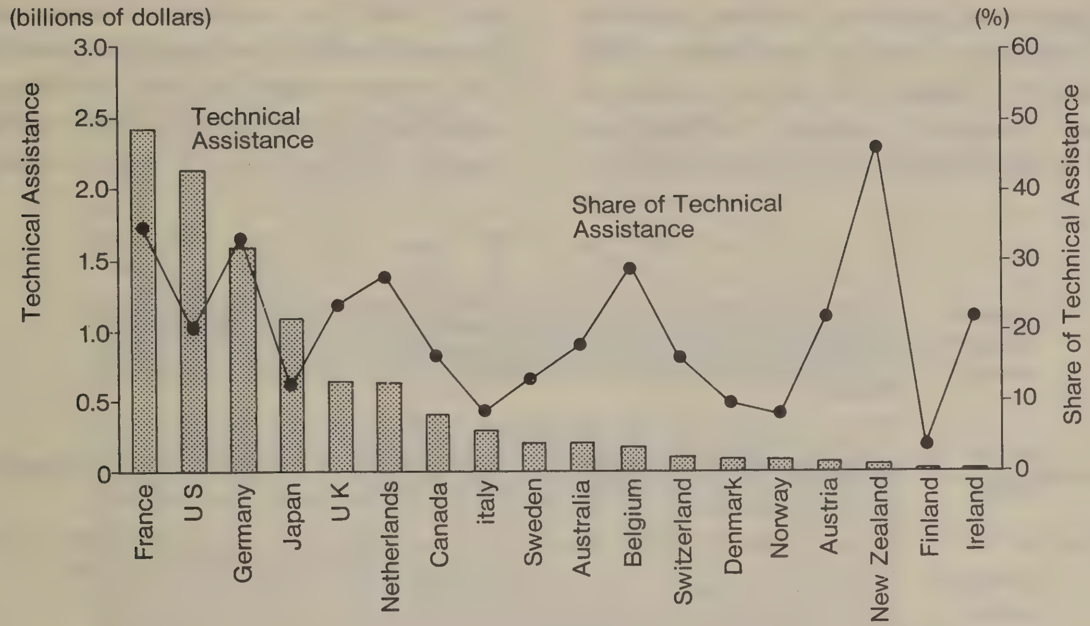


Figure 1-1-42. ODA technical assistance by DAC countries (1988)

Source: Ministry of Foreign Affairs: "Japan's ODA"
Citation: DAC reports

cooperation.

Japan has been taking steps to achieve these medium-term goals, and its total amount of assistance became the world's largest in 1989 (Figure 1-1-41). Japan's technical assistance excluding monetary assistance ranks the 4th (Figure 1-1-42).

1.1.2.3. Activities of Private Companies

1.1.2.3.1. Domestic and International R&D Activities by Japanese Private Companies

1.1.2.3.1.1. Establishment of R&D Facilities Overseas

(1) Scales

When globalizing their business activities, Japanese companies first began by establishing bases for sales activities, followed by those for production. In recent years, they have been setting up overseas facilities dedicated to research and development.

The Science and Technology Agency conducted "the Survey on Private Enterprises' Research and Development" in June 1991 (hereinafter referred to as the "Survey on private enterprises' R&D); the number of companies surveyed was 1,301, of which 850 responded. According to the survey, Japanese companies have a total of 276 overseas R&D facilities; 14% of the respondent companies have such overseas facilities. By capital size, 17% of companies with capital of over 10 billion yen but less than 50 billion yen already have such centers overseas, compared with 8% of those having capital of less than 10 billion yen. Nearly half of those companies with capital of more than 50 billion yen have overseas R&D facilities (Figure 1-1-43). Those companies not having overseas facilities gave two principal reasons -- R&D facilities

within Japan are sufficient for them, and they cannot afford the cost of establishing R&D operations. By region, the largest number of Japanese companies' research facilities are located in the US, followed by Western Europe. After 1985, the number of these facilities increased sharply; accordingly they were built in a variety of countries/regions. In coming years, companies plan to establish R&D facilities in Western Europe, taking into account the

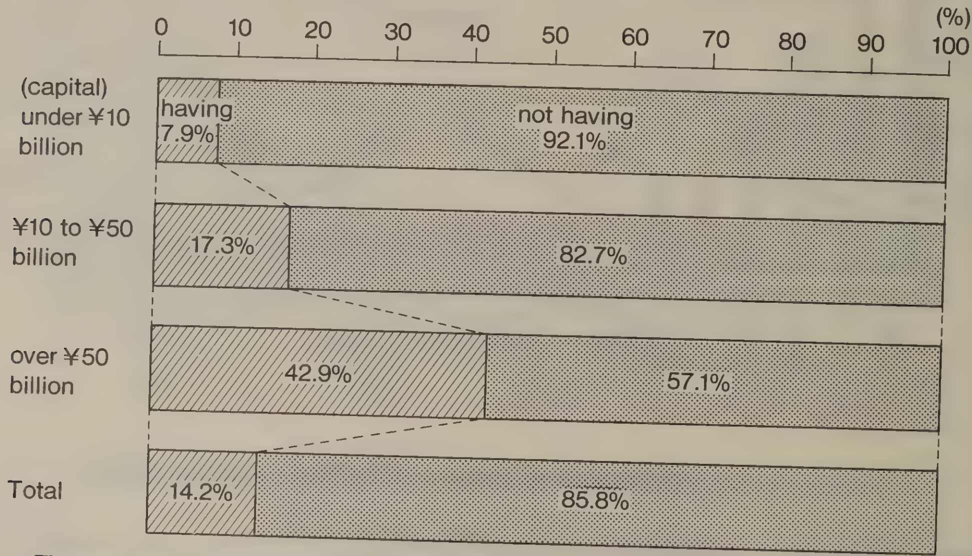


Figure 1-1-43. Percentage of private corporations having overseas R&D facilities

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

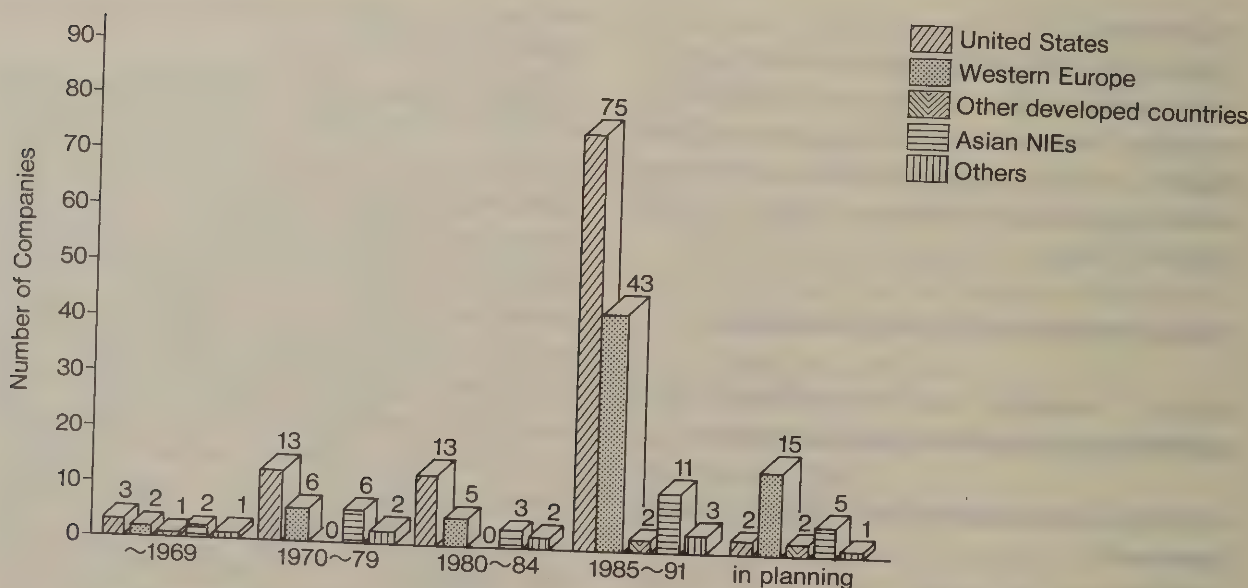


Figure 1-1-44. Period of establishment of the first overseas R&D facilities in each region

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

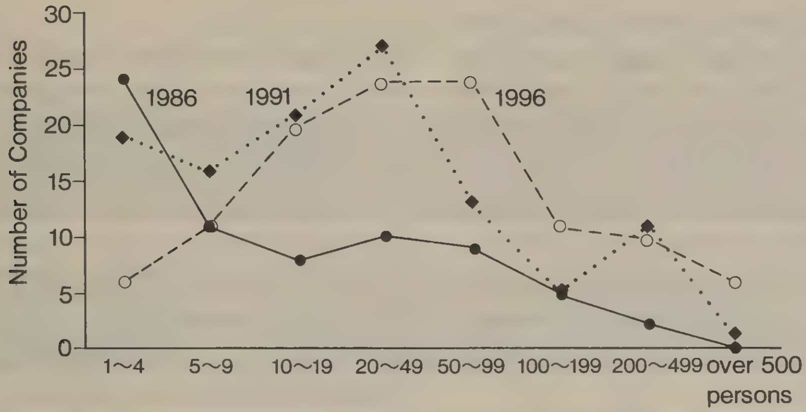


Figure 1-1-45. Total number of R&D personnel employed in overseas R&D facilities per company

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

forming of the single market there (Figure 1-1-44).

On average, each Japanese company has altogether between 20 and 49 researchers working at overseas R&D facilities. Compared with the figure 5 years ago when a majority of companies had 1 to 4 researchers overseas, the number of researchers working at their overseas R&D facilities has been increasing steadily. According to their plans, within five years more companies will average 20 to 99 researchers (Figure 1-1-45). As for the nationalities of researchers employed at these overseas R&D facilities currently, foreigners outnumber Japanese. This is a sharp increase in foreigners compared with five years ago when the ratio of foreign and Japanese researchers were almost the same. Most of these companies plan to increase foreign researchers, i.e., hardly any company is planning to have more Japanese than foreigners in its overseas R&D facilities five years from now. This indicates that R&D activities overseas will be conducted mainly by foreign researchers in the future (Figure 1-1-46). The survey results show that the number of R&D facilities of Japanese private companies have been increasing rapidly in recent years. Consequently, employment of foreign researchers has been increasing. As mentioned in more detail in Chapter 2, through appropriate measures, such as publishing the results of company research activities, consideration should be given for preventing the misunderstanding that Japanese companies are monopolizing talented people overseas for their own sake. The initiative which Japanese companies have displayed by establishing overseas research facilities contrasts with that of foreign companies which take longer to establish their research facilities in Japan.

(2) Objectives of Establishing R&D Facilities Overseas

Japanese companies with R&D facilities overseas have the following four points as their objectives:

- To upgrade already existing productional facilities (strengthening links between production and research activities);
- To meet specific needs overseas, and to improve products (developing products that meet local needs);
- To search for the seeds of new technology (basic research);
- To employ and utilize excellent R&D staff

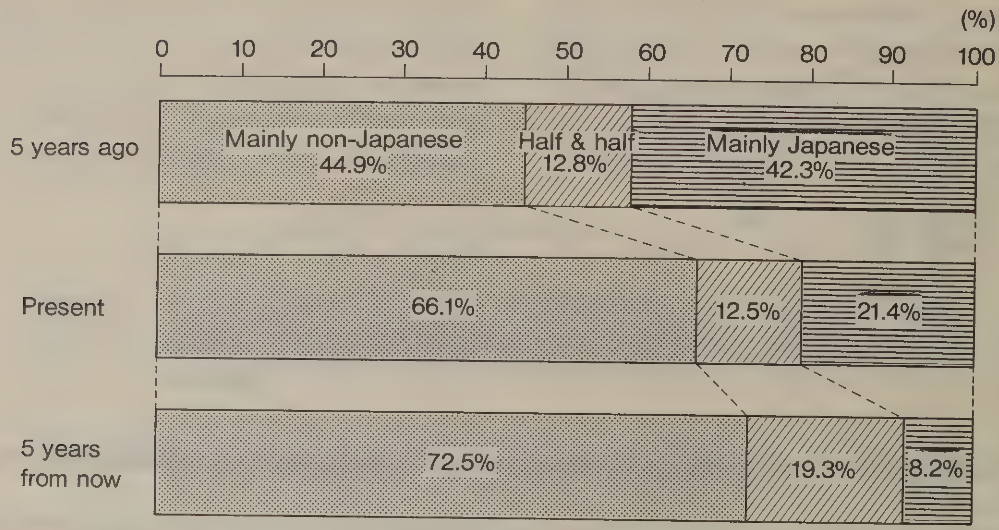
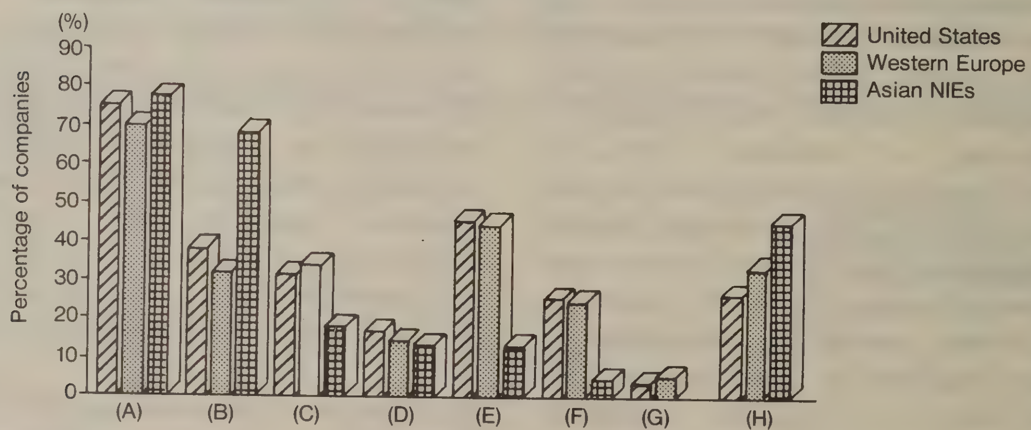


Figure 1-1-46. Nationalities of researchers employed in overseas R&D facilities

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"



(A) To meet the local needs
(B) To upgrade already existing production facilities
(C) To employ and utilize excellent R&D staff
(D) Acquired as part of a company involved in a merger or take over
(E) To search for the seeds of new technology
(F) To cooperate with foreign university and/or company
(G) To stimulate the activity of the whole company
(H) Other reasons

Figure 1-1-47. Motivations of Japanese private corporations for establishing overseas R&D facilities

Note: Multiple response

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

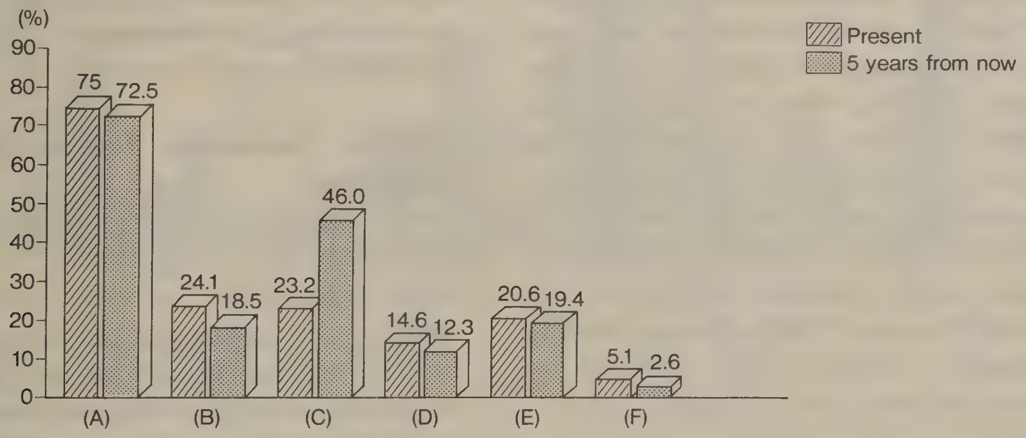
overseas.

R&D for local needs and product improvement has been the reason cited by most the companies, indicative of the companies' policy to meet the market needs. As for other objectives, companies expect different effects in different countries. A large number of companies expect in the US and West European countries to "search for the seeds of new technology". In newly-industrializing Asian countries, they principally expect "To upgrade already existing production facilities (strengthening linkage between production and research)", and "to meet overseas needs and improve products", but they have less expectation that these R&D centers will "Search for the seeds of new technology" and "employ excellent R&D staff" (Figure 1-1- 47).

18% of the respondents replied that successful results have been obtained in conducting R&D "to meet overseas needs, and to improve products". This indicates that their programs for developing products meeting local needs have not yet progressed smoothly. 27% replied that they had achieved some successful results in "upgrading already existing production facilities". Regarding the employment of skilled R&D staff, results have not been favorable with only 5% replying positively. This illustrates that Japanese companies are facing difficulties in employing personnel who meet their standards both inside and outside Japan.

(3) Contents of Research Activities at Overseas R&D Facilities

The contents of research activities at overseas R&D facilities are closely connected to the reasons these facilities were established. In most cases, research activities are dedicated primarily to "Developing products for local markets", and secondly to "Improving production efficiency". Efforts to "develop core technologies" are not very active, reflecting the fact that such efforts



(A) Development of products meeting local market
(B) Research for higher production efficiency
(C) Development of core technology
(D) Research for meeting local rules and regulations
(E) Basic research
(F) Others

Figure 1-1-48. Nature of research at overseas R&D facilities of Japanese private corporations

Note: Multiple response
Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

by companies are mainly made in Japan. However, in planning for 5 years from now, more companies responded that their overseas R&D facilities will "Develop core technologies" than they will "Improve production efficiency". The percentage of companies conducting "basic research" overseas is small, and most of them foresee no change in this (Figure 1-1-48).

(4) Management of Research Activities at Overseas Research Facilities

Issues in managing overseas R&D activities differ depending on when and where the facility was established. Poor communication and linkage between overseas R&D facilities and their Japanese headquarters or between facilities and overseas production sites were mentioned as the problem when R&D facilities were established in Europe and America or Asia, but they are less serious at present. Many companies do not foresee these as problems in the future. Frictions due to "local government regulations and institutions" which also were regarded as a problem in the past when R&D facilities were established in Asia have been subsiding in recent years. "Difficulties in recruiting R&D staff" is considered one of the serious present and future problems by companies having facilities in Asia. Possible future issues commonly referred to by companies having overseas facilities in US, Europe, and Asia are; "R&D efficiency leading to successful results", and "handling of intellectual property rights" (Figure 1-1-49).

(5) Joint Activities with Local Research Organizations

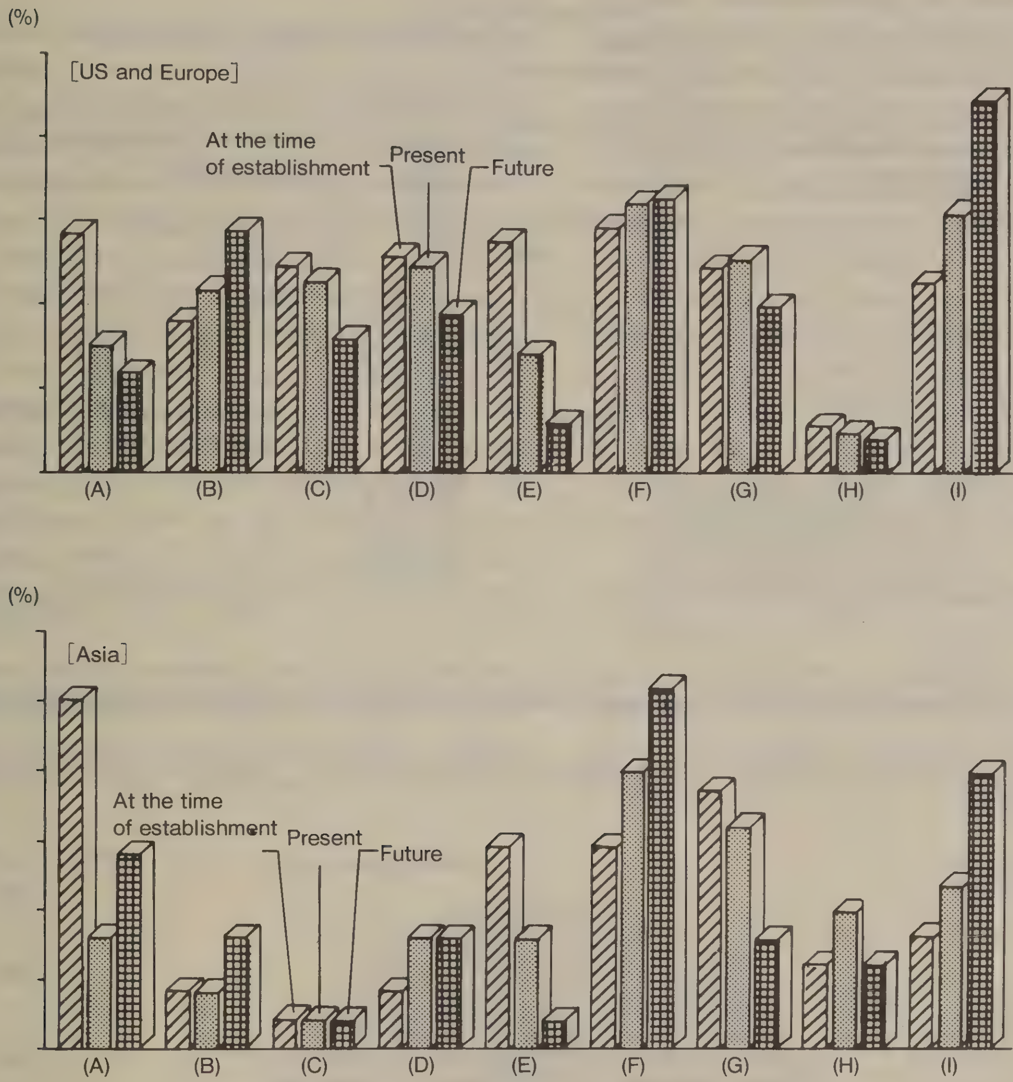
83% of Japanese companies' overseas research facilities are conducting joint research activities with universities/colleges, companies, or with government organizations in the locality. On the average, each company has two ongoing collaborative research projects, doubling the average of 5 years ago. This indicates that Japanese companies are positively inclined toward joint research activities with overseas local researchers.

(6) Cooperation with Universities/Colleges

Japanese private companies have been active in cooperative programs with Japanese and with foreign universities and colleges. The total amount of donations and contracted research funds provided by these companies to Japanese universities/colleges is much larger than that provided to foreign institutions. 24% of the respondent companies replied that they have provided funds to foreign institutions. The total amount of funds from one company is in most cases from 10 million to 100 million yen, either to domestic or to foreign institutions. The amount of funds by companies having capital of 10 million yen or more is larger than that by companies capitalized with less than 10 million yen (Figure 1-1-50). It is expected that joint research activities with overseas universities/colleges will increase as private companies pursue the globalization of R&D, and as opportunities for exchanges with overseas universities/colleges increase.

1.1.2.3.1.2. Technology Transfer by Private Companies

64% of respondent companies have experiences in technology trade, i.e., export or import of technology in forms of patent license transfer of know- how and technology guidance etc. 36% of the companies are involved in both technology export and import, indicating their positive attitude toward providing and accepting technology across international borders. 70% of the exporters replied either that their importers are not their overseas subsidiaries, or that non-subsidiary importers outnumbered their subsidiaries. This indicates that companies are active in overseas technology transfer and are not limiting their trade partners to their own subsidiaries (Figure 1-1-51).



(A)Local government regulations and institutions
(B)Handling of intellectual property rights
(C)High cost of establishing R&D operations
(D)Insufficient general strategy of the company
(E)Linkage and communication with production side
(F) Difficulties in recruiting R&D staff
(G)Insufficient human resources from parent company
(H)Low rate of researchers remaining at the facility
(I) R&D efficiency leading to successful results

Figure 1-1-49. Problems of research management at R&D facilities of Japanese private corporations in the US, Europe and Asia

Note: Multiple responses
Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

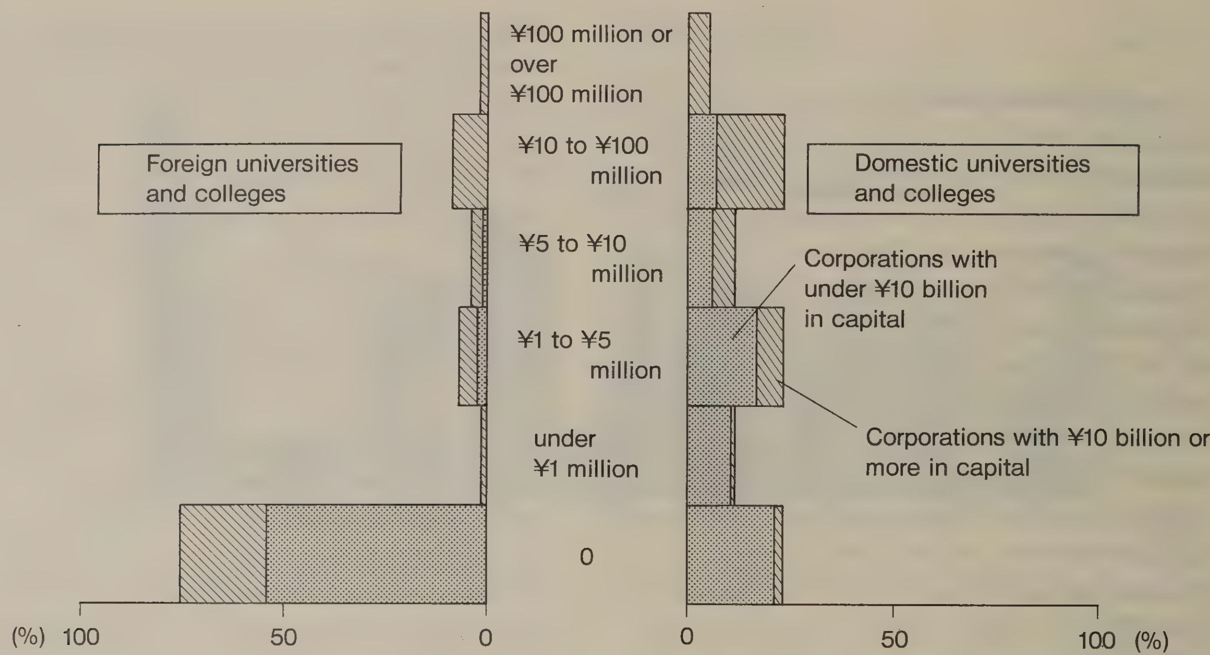


Figure 1-1-50. Flow of R&D funds from Japanese private corporations to universities/colleges in FY1990

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

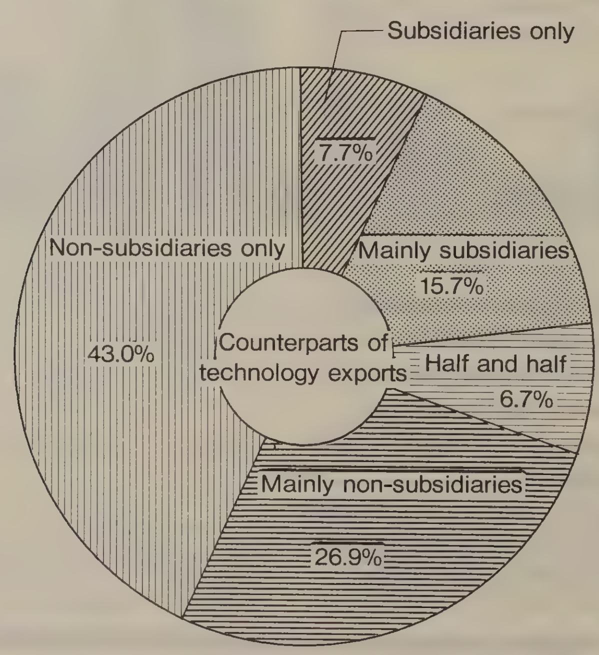


Figure 1-1-5l. Technology export partners of private corporations

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

1.1.2.3.1.3. Technology Transfer to Developing Countries

Technology transfer encourages the narrowing of the economic gap between countries in the north and the south. Developing countries have been seeking Japanese technology to help launch their takeoff for economic prosperity. Technology transfer from Japan to Korea has increased sharply; transfers to Thailand, Taiwan, Singapore, and Malaysia also have been rising. Transfers to Indonesia have leveled off, and technology transfer to China has been decreasing after peaking in 1984. Transfer to the Philippines has not been active so far. So far, vigorous economic activity is the motivator for the introduction of technology from Japan (Figure 1-1-52).

Among different forms of technology transfer, establishing factories results in tangible effects of such transfer in the shortest term. Direct investments into developing countries by Japanese manufacturing industries have been increasing; they have centered on establishing plants and factories for local production. Various technology and management expertise brought in by Japanese private companies are expected to contribute to the development of the local economy. According to the "Survey on Private Enterprises' R&D", most of the responding companies regard the newly-industrializing countries of Asia not as places for R&D itself but as places for developing products including production support (Figure 1-1-53). Consequently, in Asian NIEs, Japanese companies transfer technology and conduct technological guidance centering on their production centers.

1.1.2.3.1.4. Employment of Foreign Researchers

According to the "Survey on Private Enterprises' R&D", employment of foreign researchers at corporate R&D facilities in Japan has been increasing rapidly, tripling in the past three years to a total of 751. However, this figure

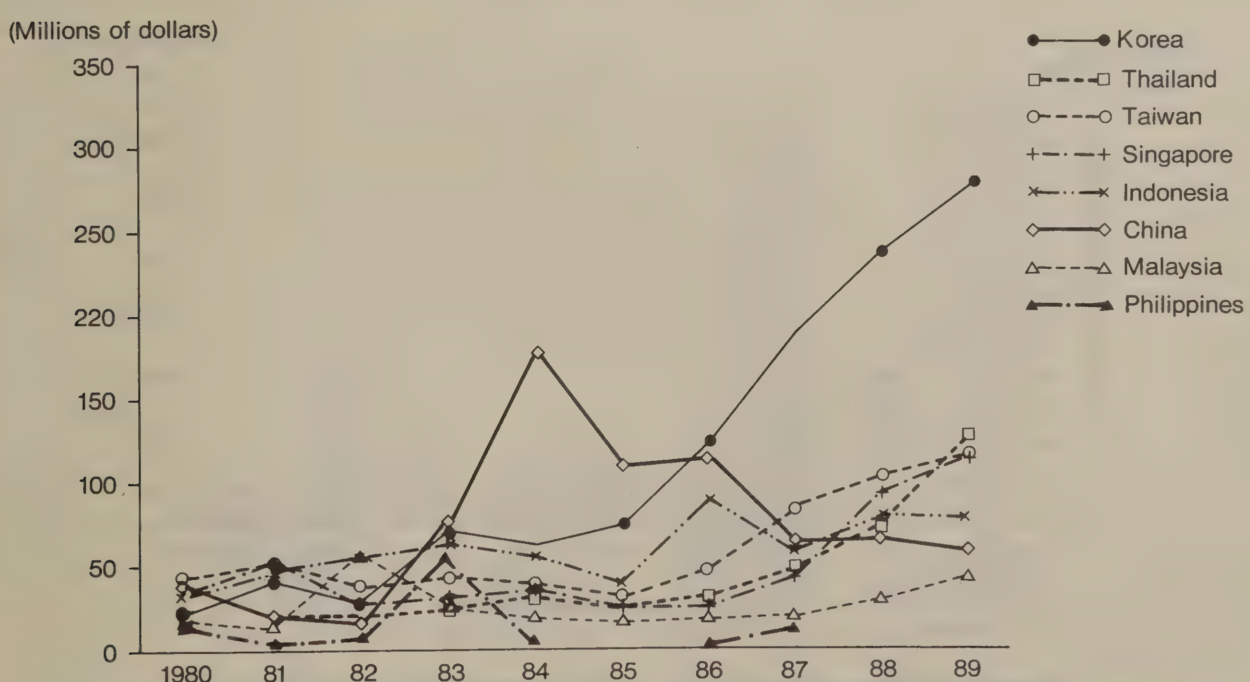


Figure 1-1-52. Trends in technology exports by Japan to neighboring countries (area)

Source: Management and Coordination Agency, the Statistics Bureau: "Report on the Survey of Research and Development"

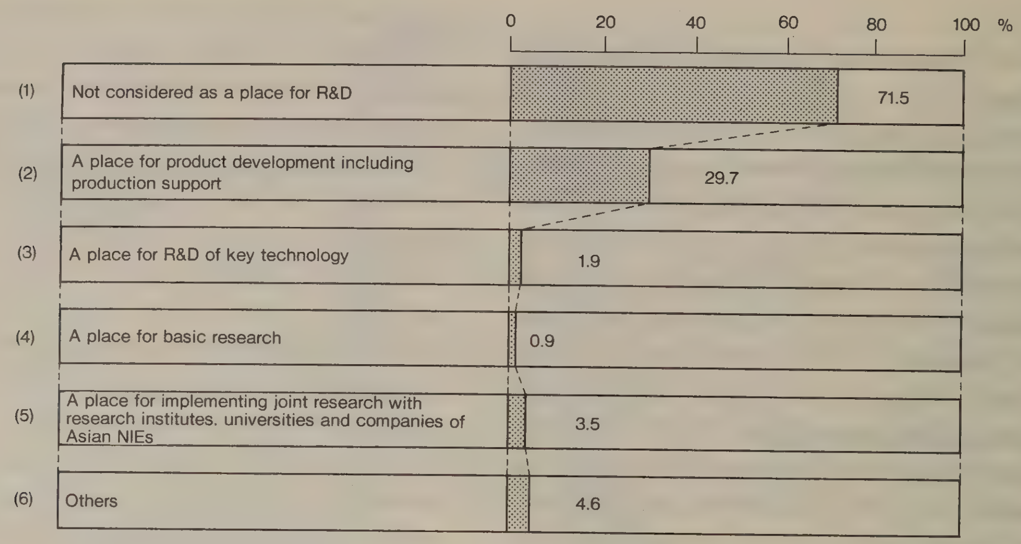


Figure 1-1-53. Position of Asian NIEs seen by private companies in the context of R&D strategy

Note: Multiple response

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

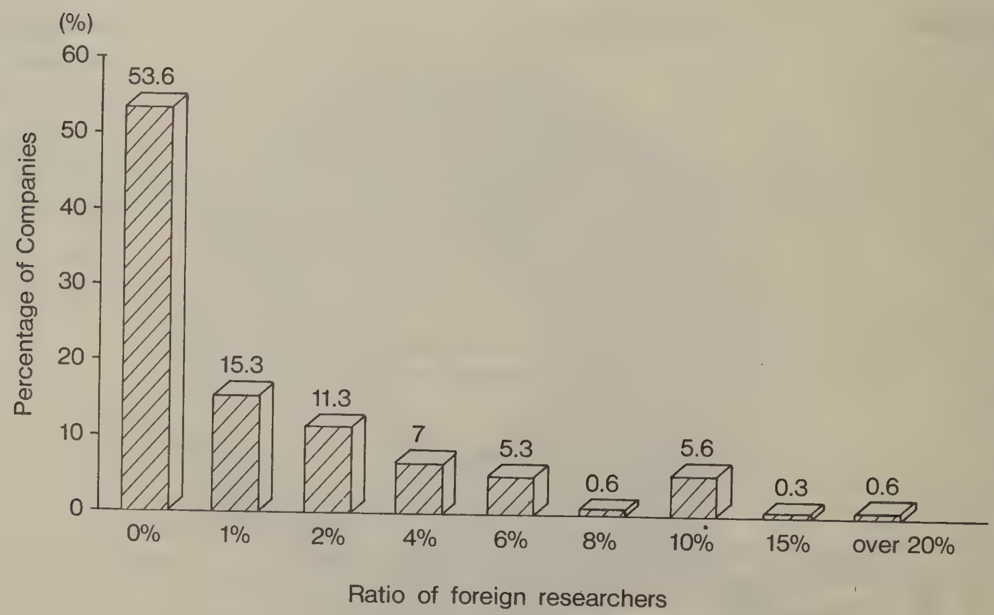


Figure 1-1-54. Expectations for the ratio of foreign researchers employed by private corporations in Japan in the future

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

is still smaller than the total number of respondents. This number is also far less than 1% of researchers in the companies. Companies have different plans for the composition of their personnel.

If the ratio of foreign researchers continues to increase, they will impact on the company's management of research activities and on its culture. 40% of responding companies gave forecasts concerning the ratio of foreign researchers in the future. 15% of those companies replied that they would keep foreigners in R&D at around 1%, but twenty companies hope to make this proportion over 10%. This indicates that companies have quite different strategy for employing foreign researchers (Figure 1-1-54).

The largest number of foreign researchers working in Japanese R&D facilities come from Asian countries, followed by those from Western Europe and the US. The number of Asian researchers increased sharply in the past three years, reflecting the fact that students at Japanese universities/colleges continue to stay in Japan to work for Japanese companies after completing their studies (Figure 1-1-55).

The most important reason Japanese companies employ foreign researchers at their domestic R&D facilities is to "secure manpower", reflecting the shortage of researchers in Japan. The second reason is to pursue higher quality of research activities, as indicated from replies; "development of new technology stimulated by different ways of thinking by foreign researchers", and "breakthrough which cannot be expected from Japanese researchers" (Figure 1-1-56). However, few companies replied that they are obtaining successful results as they expected. They will continue in the future to deal with issues of effective management of foreign researchers.

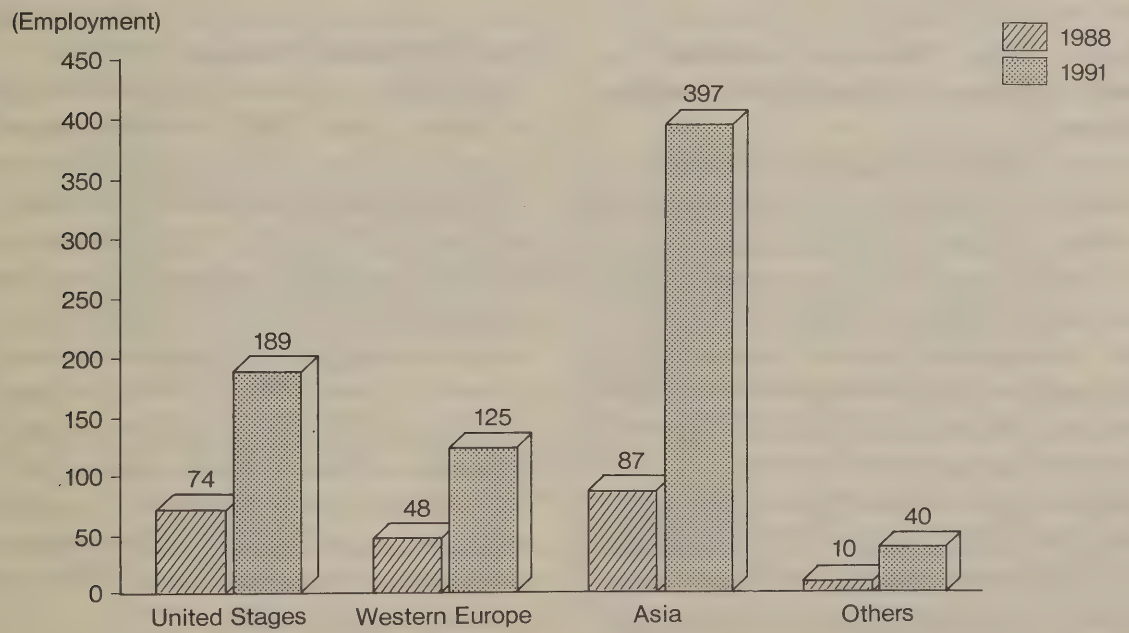


Figure 1-1-55. Foreign R&D personnel employed by private corporations in Japan (by nationality)

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

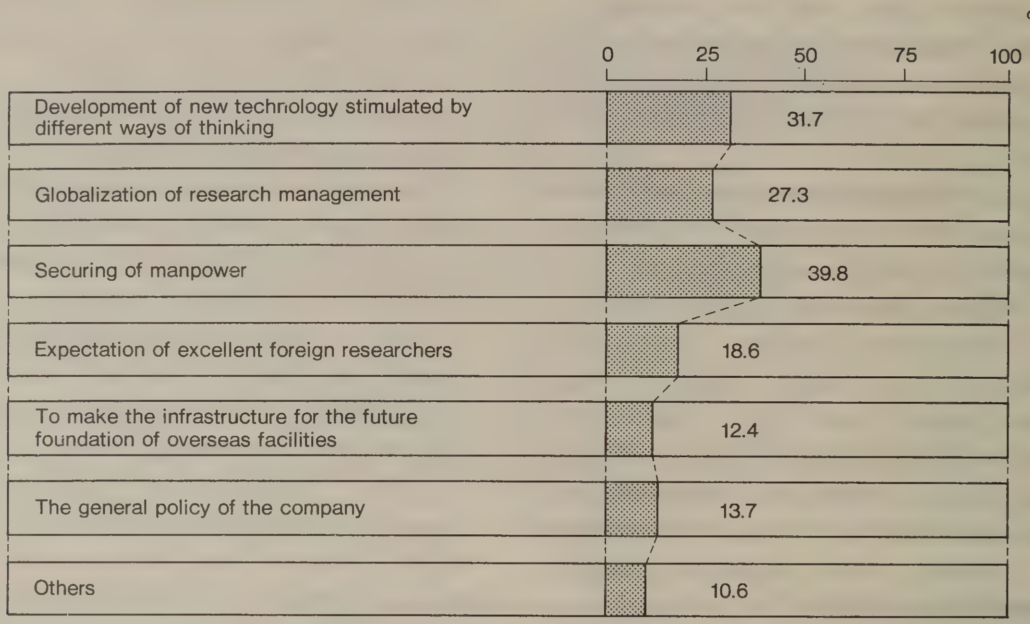


Figure 1-1-56. Reasons to employ foreign researchers at R&D facilities

Note: Multiple responses
Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

1.1.2.3.1.5. Joint Research Activities by Domestic Japanese Companies with Overseas Institutions

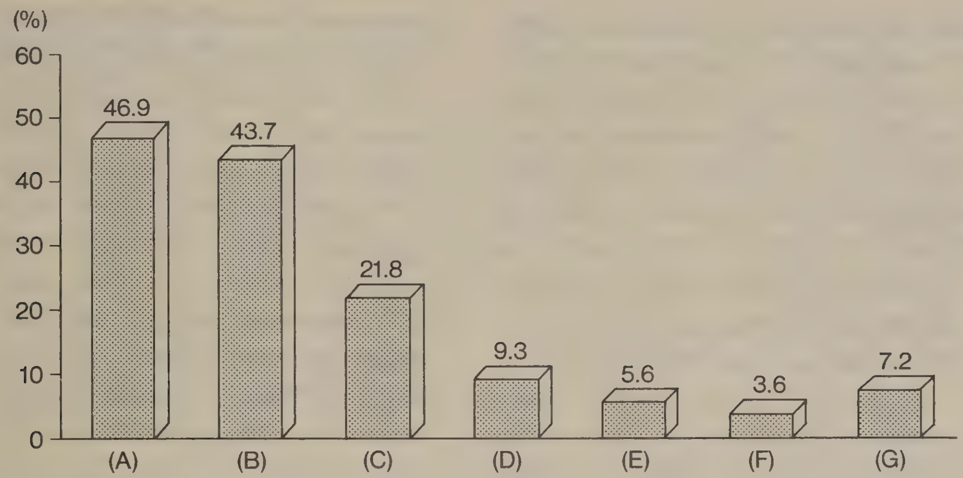
Currently, 35% of Japanese companies are conducting joint research activities with overseas universities/colleges, companies and government organizations. While the average number of such collaborations per company is 5, both the number of companies involved and the number of collaborations are much larger than they were 5 years ago, indicating that such joint research activities are becoming more active.

Companies gave several reasons for implementing such joint efforts. Most important were, "Searching for original ideas and unique technology in the particular technological area", and "Shared efforts for new product development". The third reason given was "A step toward future globalization of the company" (Figure 1-1- 57).

1.1.2.3.1.6. Future Prospects

60 percent of Japanese companies intend eager to develop their R&D activities beyond the country's border. 24% of the companies plan to have their core R&D facilities in Japan, with overseas complementary R&D activities to meet the local production technology requirements and the needs of local markets. 21% of the companies plan to have a complex approach, i.e., to conduct core R&D activities in Japan and auxiliary activities overseas, but to put more emphasis on R&D in North America and other big markets with relatively independent strategies. In contrast, 34% of the companies are not planning to expand their R&D activities overseas (Figure 1-1-58).

Until recently, Japanese private companies focused on R&D activities within the country. Effective cooperation among their domestic research facilities ensured high efficiency in R&D activities. Lately, companies have been



(A) Search for original idea and unique technology
(B) Shared efforts for development of new products
(C) A step toward globalization
(D) Joint research with domestic companies is difficult
(E) Establishment of common standards of products
(F) Other objectives than joint research itself
(G) Others

Figure 1-1-57. Reasons for domestic R&D facilities conducting joint research with overseas companies

Note: Multiple responses
Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

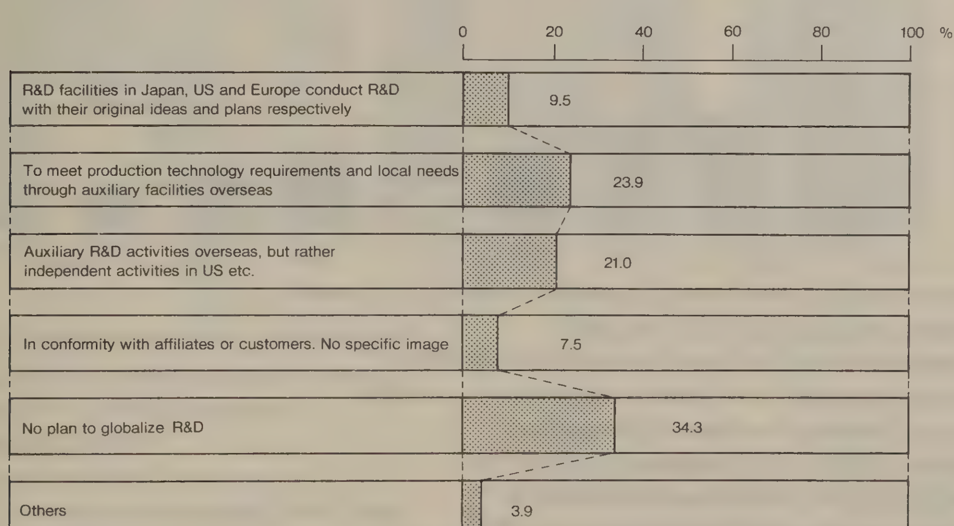


Figure 1-1-58. Future image of international development of R&D activities by private companies

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

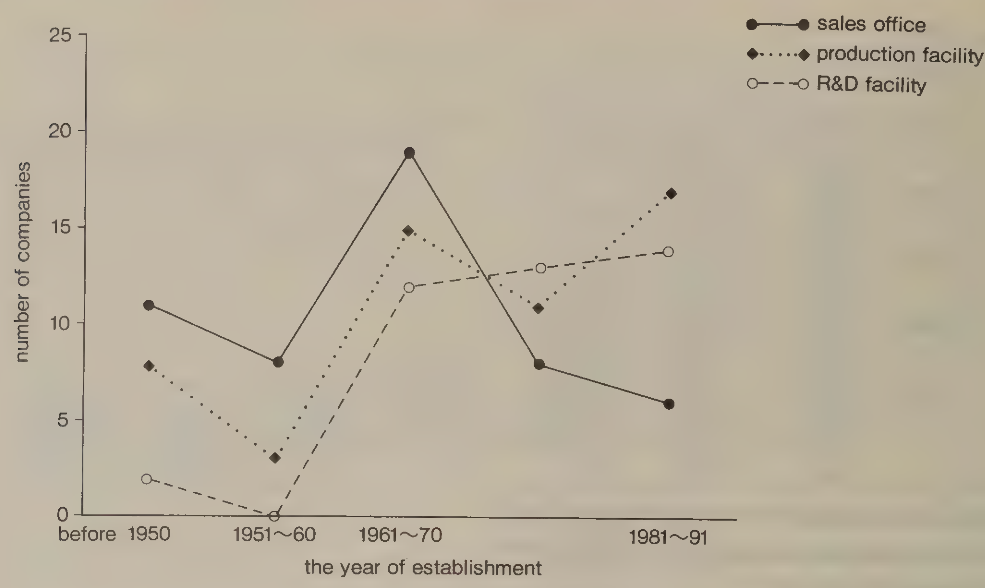
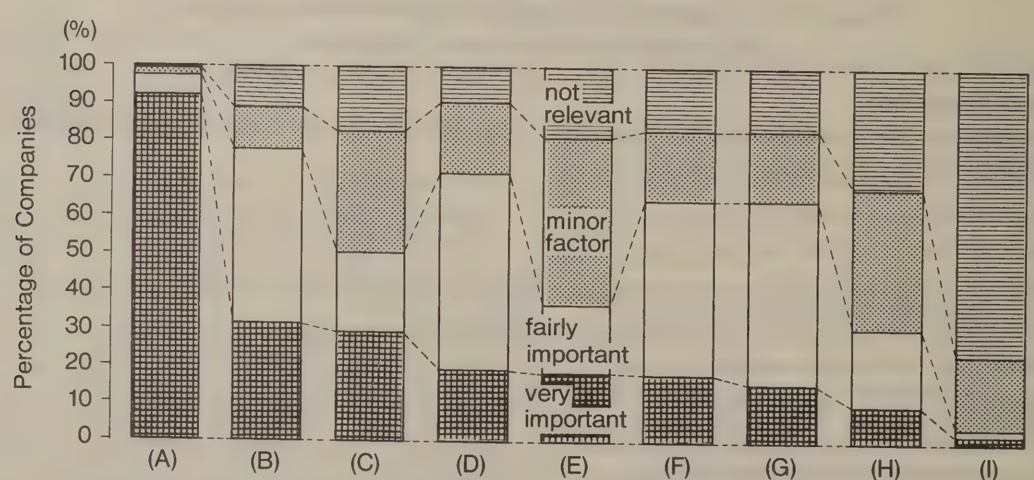


Figure 1-1-59. Period of establishment of foreign-affiliated companies in Japan

Source: National Institute of Science and Technology Policy, STA



(A) To plan and localize new products meeting host country needs
(B) Japan seen as leader in R&D in my field
(C) To monitor technological developments and activities
(D) Japan seen as leader in production technology in my field
(E) To conduct strategic analysis of competitors
(F) Existence of outstanding engineering personnel
(G) Existence of outstanding research personnel
(H) To upgrade already existing production facilities
(I) Japanese government incentives

Figure 1-1-60. Reasons foreign-affiliated companies conduct R&D in Japan

Source: National Institute of Science and Technology Policy, STA

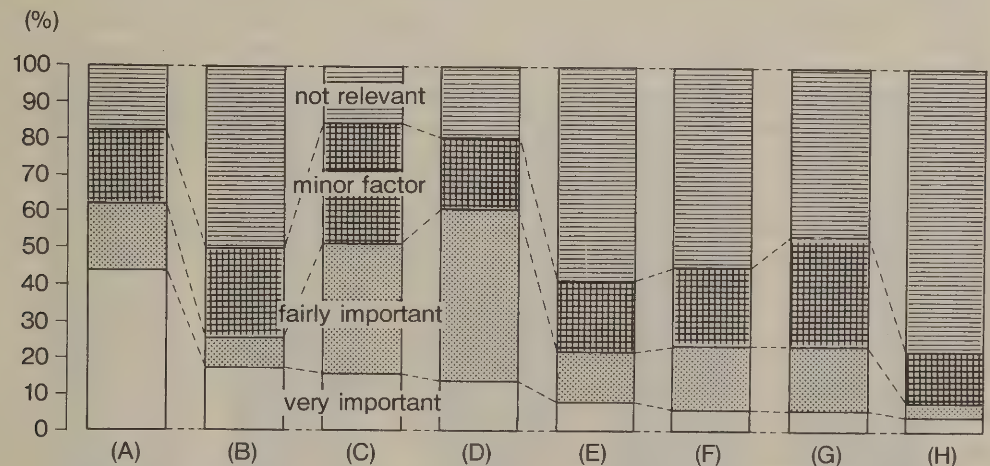
active in establishing research facilities overseas. Their next step is to obtain successful results from these R&D facilities. They will need to ensure consistency with the headquarters' strategies, as well as with other overseas R&D facilities. Also, as highly qualified researchers are employed at overseas R&D facilities, companies will need to develop effective management methods for the personnel. The companies also must ensure that the results obtained through research activities will contribute to the benefit of the local community.

1.1.2.3.2. R&D Activities of Foreign Companies in Japan

1.1.2.3.2.1. Background of Foreign Companies Establishing Research Facilities in Japan

Japanese private companies became in earnest to establish their R&D facilities overseas after 1985. According to the survey made by the National Institute of Science and Technology Policy of the Science and Technology Agency, foreign companies first built sales centers in Japan, then production centers, and R&D facilities (Figure 1-1-59). They began establishing these R&D facilities in the 1960s, and increased their numbers gradually since that time. This is in contrast to Japanese companies which built their overseas R&D facilities during a short period of time.

The roles of the foreign companies' research centers in Japan are to develop technologies connected directly to production, and to develop products which meet local demands. Consequently, the largest percentage of foreign companies replied that they established these centers in Japan, "To plan and localize new products", followed by replies; "Japan seen as leader in R&D in my field", and "To monitor technological



(A) Proximity to other affiliate-related facilities
(B) Location gives laboratory competitive edge
(C) Ability to attract potential employees
(D) Favorable land prices
(E) Regional government incentives
(F) Proximity to government research institutes
(G) Proximity to universities
(H) Japanese government incentives

Figure 1-1-61. Reasons foreign affiliated businesses chose present site for their R&D centers

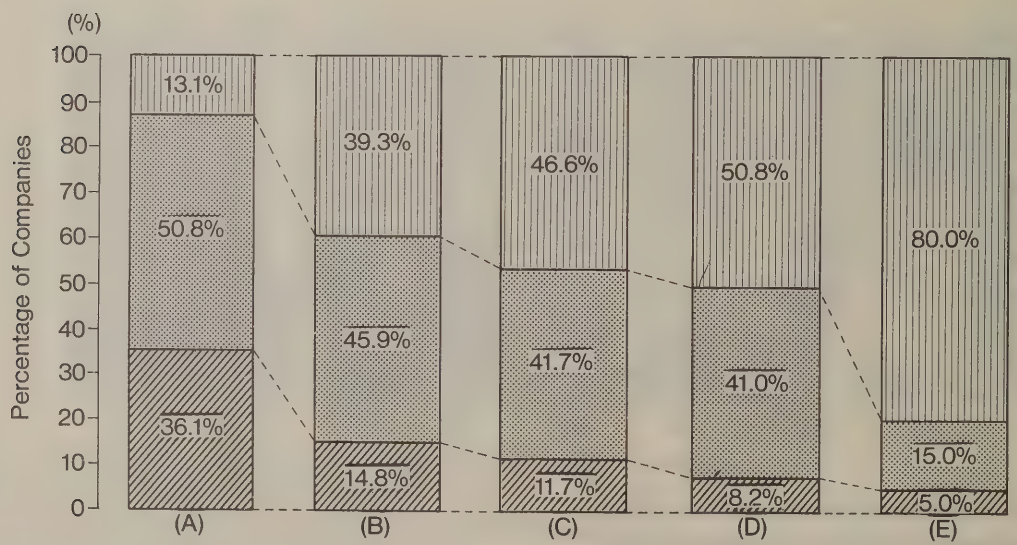
Source: National Institute of Science and Technology Policy, STA

developments and activities". This indicates that foreign companies consider Japan as a desirable location to conduct R&D activities (Figure 1-1-60). They located their R&D centers close to their production centers. Land price also was one of the decisive factors in selecting the locations of the centers (Figure 1-1-61).

64% of the foreign R&D centers in Japan have only Japanese researchers and engineers. This is related to the aim of centers to develop "Products which meet the Japanese market". Their aim of placing importance on local needs is also seen when new R&D projects are launched. Although ideas for these projects are brought mostly from the researchers, other important factors in deciding research themes are demands from customers and feedback from sales and marketing divisions.

1.1.2.3.2.2. Problems Faced by Foreign Companies

Foreign companies with R&D centers in Japan are faced with problems such as, "Difficulty in attracting qualified research personal", "High cost of establishing R&D operations" and "Patent office procedures". The issue of securing high quality manpower is also a serious issue for Japanese companies. It is urgent for Japan to provide sufficient infrastructure including taking measures to alleviate the problem of high land prices. As for patents, each country has a different system, and efforts to achieve greater consistency and flexibility between the systems of various countries will be necessary. 80% of the responding companies, however, reported no problems with rules and regulations of the Japanese government (Figure 1-1-62).



(A) Attracting qualified research personal
(B) High cost of establishing R&D operations
(C) Patent office procedures
(D) Harmonizing research activities with parent company
(E) Government regulations

Figure 1-1-62. Problems foreign-affiliated companies face in carrying out R&D activities in Japan

Source: National Institute of Science and Technology Policy, STA

Table 1-1-63. Influence and damage due to global environmental changes

Phenomenon	Outline
Global Warming	The increasing density of CO_2, CFCs, methane and other gases which cause the greenhouse effect may warm the entire earth. If the current tendency continues, the average temperature of the earth is expected to rise about 1 degree centigrade by 2025, and the sea level about 20cm by 2030. There are concerns about warming effects, such as abnormal weather, damage to agricultural production and the ecosystem, and territorial conditions.
Destruction of the ozone layer	The ozone layer in the stratosphere is destroyed by increasing amounts of CFCs, causing increases in hazardous ultra-violet rays, resulting in more cases of certain types of skin cancer. Besides being hazardous to human health and the ecosystem, destruction of the ozone layer would adversely affects global weather.
Acid rain	Sulfur oxide and nitrogen oxide generated by burning of fossil fuel cause strong acid rain which damages forests and lakes especially in Europe and North America.
Cross-border movements of toxic wastes	Illegal exports of harmful wastes from developed countries to developing countries are causing environmental problems.
Marine pollution	Pollution of the oceans is increasing due to oil, floating wastes and harmful chemical substances.
Decrease in species of wild life	Five hundred thousand to a million wild life species are predicted to become extinct by 2000 due to destruction of their habitats.
Decrease of tropical forests	Slash-and-burn farming, over-gathering of firewood, conversion of forests to farmland, over-grazing of cattle, over-lumbering of commercial wood materials are considered to be the causes of shrinking tropical forest areas, which become smaller by 1.7 million ha. (half of land area of Japan) every year. The decrease in tropical forests endangers developing countries bases for living and industry, and wildlife habitats as well. It also causes weather changes, soil erosion, and global warming.
Desertification	Due to over-grazing and over-collection of firewood, deserts are expanding by 6 million ha. (equal to Shikoku and Kyushu combined) each year. Concerns are damage to local residents' necessities of life such as food and firewood, as well as effects on the weather.
Pollution in developing countries	Developing countries already are facing pollution problems due to industrialization and concentration of population in cities, and need solutions through international cooperation.

1.1.3. New Issues

The previous section mainly analyzed the state of science and technology in Japan, along with the development of globalization in scientific and technological activity.

This section deals with two international issues which have become increasingly important and which require international cooperation for solutions -- global environment issues and megascience projects. In doing so, this section, apart from the domestic viewpoint, explains that the promotion of science and technology now must also include the aspects of international cooperation, and analyzes those situations.

1.1.3.1. The Global Environment Issue

Concern about the global environment has been rising throughout the world in recent years. People expect science and technology to deal with various global environmental issues through observation/surveillance of the environment, analysis of environmental changes, and development of technology to solve various problems.

1.1.3.1.1. Science and Technology and the Global Environment

1.1.3.1.1.1. Global Environmental Issues

Global environmental issues include problems which affect more than one country and spreading globally, such as global warming; and environmental problems in developing countries which require international efforts and developed countries for their solution, such as the issue of cross-border transfers of harmful organic wastes. Table 1-1-63 lists major global environmental issues, e.g. "Global warming", "Destruction of the ozone layer", and "acid rain".

These phenomena could seriously affect our basic survival. Global warming may cause: (1) a rise in the sea level; (2) expansion of desert areas; and (3) variations in rainfall. It has been said that if the ozone layer is destroyed and the volume of ozone decreases by 1%, the volume of ultraviolet rays reaching the surface of the earth will increase by 2%, causing increases in certain types of skin cancer by 3%. Acid rain has affected almost half the forests in Germany, the Netherlands, the UK, Switzerland and Denmark. According to one report, fish and other aquatic life in more than 4,000 lakes and ponds in Sweden also have been suffering damage because of the effect of acid rain. Additionally, expanding deserts are said to have affected 230 million people in 1984.

1.1.3.1.1.2. Causes of Global Environmental Issues and Their Relation to Science and Technology

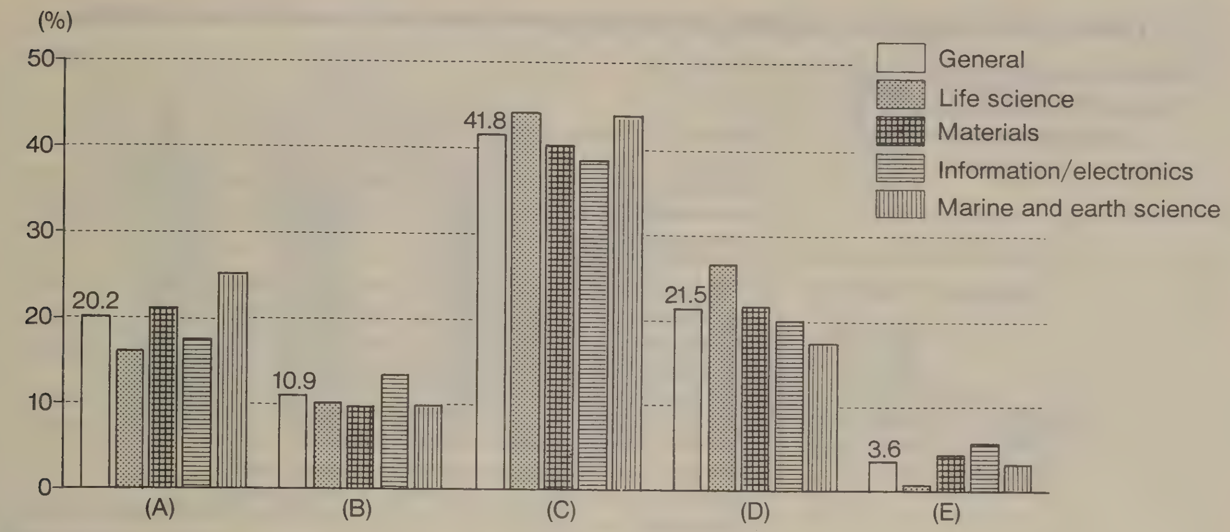
Reports which expressed fear about large scale changes and deterioration in the global environment, for example concerning global warming, were published as early as the end of 19th century. In 1972, the Club of Rome, which gathers leading personages from around the world, warned that a deteriorating global environment would restrict economic growth. In 1980, the US government published the report titled "Earth of the Year 2000" estimating the effects of the deteriorating environment in the coming years -- a shocking forecast for the readers of that time.

Why could those global environmental problems not prevented, despite warnings by these publications? Or, were the global environment problems inevitable?

Some of the causes of global environmental problems are said to purely natural phenomena unrelated to artificial effects, such as some of causes for expansion of deserts. But most of them result from human activities on the earth, such as increasing world population, huge energy consumption along with our increasing economic activities, and our development and voluminous use of products which do not originally exist in nature.

The development of science and technology enabled the development and use of products which the earth did not have originally, as well as the large-scale consumption of energy, thus accelerating economic expansion. However, such use of science and technology was directed toward serving economic goals, and we are now observing the destruction of our natural environment as a consequence (Figure 1-1-64).

Depletion of the ozone layer by CFCs, global warming due to the increase of carbon dioxide in the atmosphere, and acid rain are caused partly by the fact that science and technology were directed primarily to obtain economic benefits



(A) Problems are inevitable, and could not be avoided, regardless of researchers' consciousness or warning
(B) Environmental issues are not related to development of science and technology and researchers' ways of thinking
(C) Use of science and technology was too oriented to economic prosperity, despite researchers' recognition of the problems
(D) Use of science and technology was too oriented to economic development, because researchers did not correctly recognize the problems
(E) Others

Figure 1-1-64. Reasons for not being able to avoid global environmental problems despite warnings by experts

Source: Science and Technology Agency: "Survey of Hi-tech Researchers and Engineers, FY1991"

without considering environmental costs. Some argue, however, that these global environmental problems are the inevitable consequences of civilization.

Lack of implementing effective countermeasures to global environmental problems is attributed partly to the fact that scientific and technological approaches to these problems have not been closely connected to political decisions. Generally, policy makers and public opinion have reacted only after convincing data -- based on observations or damage surveys -- have been presented. Scientific estimates and forecasts have not been used effectively to prevent such damage before it occurs. Actually, countermeasures to protect ozone layer were taken worldwide, just after the existence of the ozone hole -- the rapid decrease in the volume of ozone above the south pole every spring-- was proved at end of 1985, because the influence on humanity originally expected to occur in the distant future, was realized as imminent. Efforts will need to be taken to ensure close linkage between policy makers and scientists so that the concern of the scientists will be reflected effectively in policy measures.

1.1.3.1.2. Future Approaches toward Solving Global Environmental Problems by Science and Technology

1.1.3.1.2.1. Scientific Investigation in Global Environmental Problem

While the global environmental problems are

Table 1-1-65. Examples of not being elucidated scientifically global environment activities

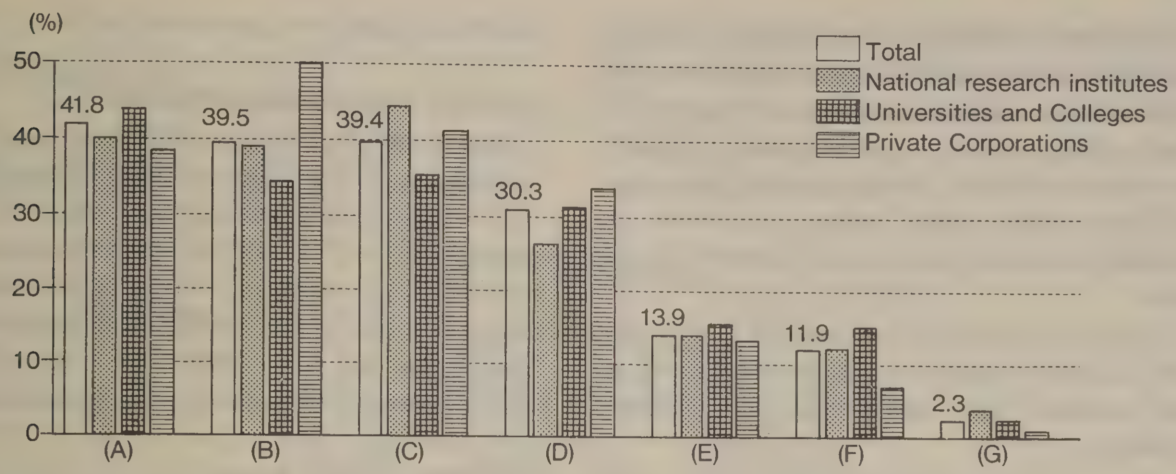
Item	Details
Circulation of CO_2	It is known that half of the carbon dioxide generated by consumption of fossil fuel remains in ambient air, but the whereabouts of the other half is not known. Possibly, it is being absorbed by the sea.
Circulation of sea water	The actual state of large scale circulation of ocean water is not known well, especially water circulation in the medium and deep layers, and formation of water mass; the dynamics of whirlpools in the surface and sub-surface layers also are not known well.
Thermal balance between land, air and sea	Ambient air, sea, and land convey heat, and the sea stores enormous heat. While it is essential to elucidate global thermal dynamics to obtain knowledge of meteorological mechanisms, the comprehensive thermal balance between the land, sea and air has not been clarified yet.
Environmental changes in the arctic region	While the effects of global warming and the decreasing ozone layer may be conspicuous in the polar regions, there is no accumulated observation data around the arctic region.
Changes in land water and snow ice regions in the northern hemisphere	Changes in the snowy regions of Eurasian continent including the Tibetan heights is one of elements influencing global weather, but no data regarding snow and precipitation in such large areas have been obtained yet.
The reason for increase of methane gas in ambient air	Reasons for increase of methane gas can be rice growing, cattle breeding, and burning of biomass. Solid organic materials under the ground, diffusion of natural gas and coal mining also can be reasons. It has not been clarified yet what the main reasons are.
Desert forming mechanisms	Recently studies have been conducted on deserts forming due to human activities, but they are only after-effect examinations. Reasons and mechanisms of natural desert forming are not fully elucidated yet.
Influence of the biosphere on the global environment	It is not clear even whether the biosphere absorbs carbon dioxide or generates it due to forest destruction. The relation of the biosphere to global material and heat circulation is not clarified yet.

Source: Science and Technology Agency

extremely serious, most causes and mechanisms have not yet been confirmed scientifically. So far, we have been able to only identify some, but not explain fully, phenomena such as increases of carbon dioxide and CFCs in the atmosphere, regional rainfall having high levels of acidity, expansion of the deserts, and reduction of tropical forests (Table 1-1-65).

In spite of increasing accumulation of scientific knowledge, it is difficult to model global phenomena in the small facilities of research laboratories. Also, an interdisciplinary approach which integrates various academic fields is necessary.

So, effort is being made throughout the world to obtain precise and sufficient data on global



(A) Improvement of living style
(B) Promotion of R&D
(C) Improvement of economic mechanisms
(D) Strengthening of regulation
(E) Assistance to developing countries
(F) Combination of various measures
(G) Others

Figure 1-1-66. Most effective measures to solve global environmental problems

Note: Multiple responses
Source: Science and Technology Agency:
"Survey of High-tech Researchers and Engineers (FY1991)"

environmental problems. Observation by satellites, in particular, is an effective way to analyze global phenomena. Programs are being undertaken to achieve comprehensive, continuous, global observation by satellites including the establishment of data networks. Thus we can gradually grasp and evaluate general global environmental conditions scientifically. Simulation modeling by high speed computers, coupled with data verified by global observation, may provide us with effective means to forecast environmental changes and analyze various phenomena.

1.1.3.1.2.2. Expectations for Science and Technology in Future

Despite their serious impact, most global environmental phenomena have not yet been explained sufficiently, and relevant studies have only just been started on most problems. Observing the global environment has become an urgent task. Efforts are being made to accumulate data and to investigate causes and mechanisms of these phenomena. To add to those efforts, it is expected that science and technology will provide scientific knowledge guiding the countermeasures for global environmental problems. We must continue conducting research.

Research and development of oil-substitute energy sources, energy-efficient technology, substitution for CFCs and technology for fixing carbon dioxide are of course effective in alleviating global environmental problems, but at the same time, we need to improve our economic activities and own lifestyles (Figure 1-1-66). To improve our economic activities and lifestyles, we need a new way of thinking other

than pursuing efficiency and amenity. Science and technology therefore has an important role to play in providing people individually on the Earth with easy to understand scientific knowledge of global environmental issues and the data from which sound judgments on desirable economic activity and lifestyles can be made.

It also is expected that science and technology will establish means to evaluate the impact of new products and technologies for extreme situations.

1.1.3.2. Mega-Science

As more and more scientific knowledge is accumulated and new research methods become available, thanks to scientific and technological development, the objectives of R&D become more sophisticated and the subjects studied are expanding. Larger research facilities become more costly and require many researchers and engineers, so one single country cannot afford those projects. Therefore, close international cooperation is required among major developed countries. Results of such joint activities should be shared by all people in the world as common intellectual property. Breakthroughs in these "mega-science" or "big science" projects are expected to open new possibilities for our future.

While most "mega-science" projects require huge and costly facilities and large groups of scientists, another category that may be included in mega-science is international cooperation by many experts through long-term cooperative studies in different fields or at many locations without such facilities. In most cases of mega-science, they are proposed by scientists. In other cases, governments take the initiative to launch these kinds of projects.

1.1.3.2.1. Examples of Mega-Science Projects

As examples of mega-science projects requiring large facilities, the space station program and the nuclear fusion project are shown here, in both of which Japan takes an active part.

1.1.3.2.1.1. Space Station Program

Japan, the US, Europe, and Canada have been cooperating in the fields of space environment utilization and manned space activities. Twelve countries signed in 1988 the inter-governmental agreement to cooperate in the Space Station program with a goal of building a manned Space Station by the year 2000. They have been working since then to develop the Space Station.

1.1.3.2.1.2. Nuclear Fusion

Based on a proposal made at the US-USSR summit in 1985, Japan, the US, the EC, and the USSR have been cooperating on the development of the International Thermonuclear Fusion Experimental Reactor (ITER), under the supervision of the International Atomic Energy Agency (IAEA), to verify that such a nuclear fusion reactor can be engineered. After the conceptual design was conducted from 1988 to 1990, it was agreed that the working sites for the joint engineering design teams would be located in Japan, the US, and Europe. Construction of ITER will be studied separately, based on the progress of the engineering design activities (Figures 1-1-67, 68).

1.1.3.2.2. International Cooperation in Mega-Science Projects

Although countries cooperate with each other in mega-science activities, their financial costs nonetheless are sizable. Each country is faced by the challenge of minimizing the adverse impact of such huge cost requirements on conventional science, or the so-called "small sciences". When promoting mega-science projects, problems which confront participating countries are, for instance, effective measures to secure funds in each country, establishment of effective management, and effective communication between scientists and between nations.

1.1.4. Summary

In the previous sections of this Chapter, various indicators were examined explaining the ongoing globalization of scientific and technological activities and the issues now facing the world. The current status and Japan's position in scientific and technological activities can be summarized as follows:

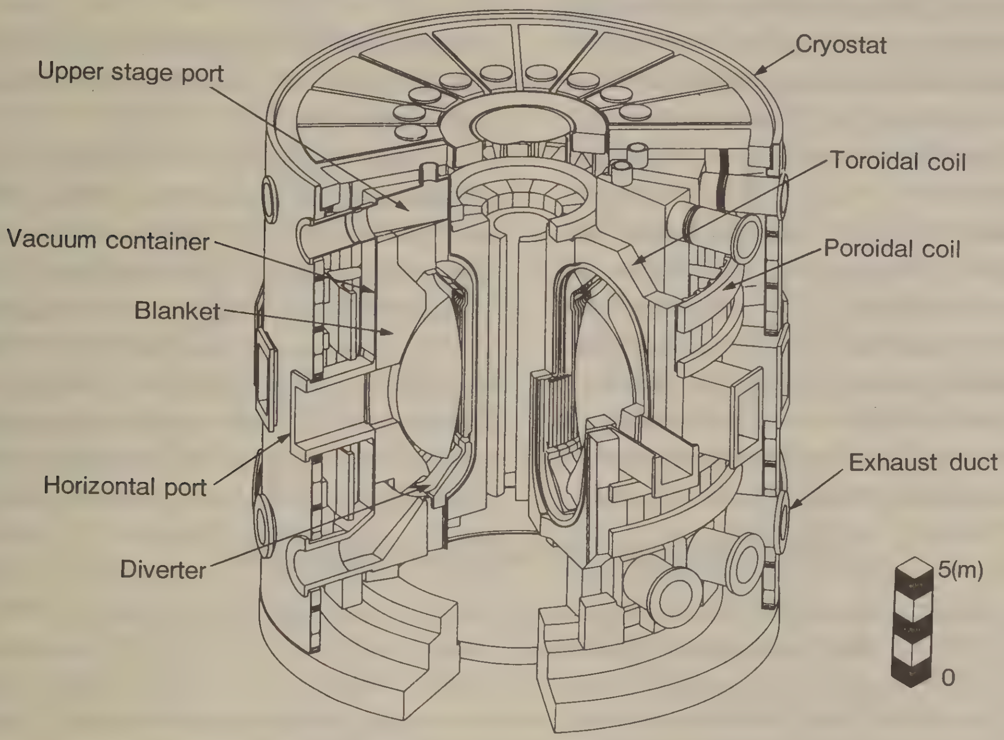
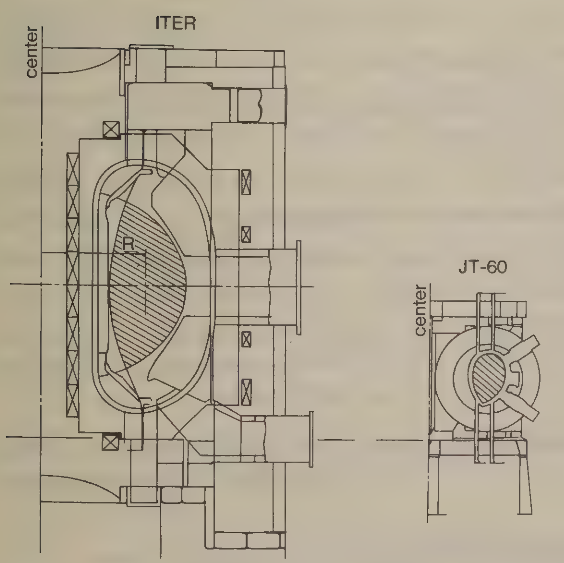


Figure 1-1-67. Structure of the international thermonuclear experimental reactor (ITER)



Name		ITER	JT-60
Size	Crown radius	6.0 m	3.4 m
	Plasma current	22-25 MA	7MA
	Plasma volume	1000 m^3	100 m^3
	Weight	24000 t	5000 t
Construction cost		about ¥700 billion	about ¥230 billion
Personnel		-	300 persons

Figure 1-1-68. Comparison of device size

1.1.4.1. Globalization of Scientific and Technological Activities

As economic activities have expanded across borders, scientific and technological activities also have been rapidly globalized, supported not only by progress in information, communication, and transportation technologies but also by the active exchange of information and knowledge among researchers of different countries.

As analyzed earlier, all indicators show that scientific and technological activities are expanding worldwide; e.g. international exchanges of researchers are increasing, more and more papers are being published and cited, increases continue in the percentage of international co-authorship, technology trade is expanding, high-tech products trade is growing, growth is occurring in manufacturing industries' overseas direct investment, and the number of overseas R&D facilities established by private companies is increasing.

1.1.4.2. Japan's Position

What position is Japan taking in the ongoing globalization of scientific and technological activities?

In basic research, the number of Japanese papers has become as large as that of the UK, and the number of cited Japanese papers has been increasing. Japan's basic research has reached almost the level of Europe, although the gap is still large between Japan and the US. However, the number of papers per researcher is still insufficient. It is the smallest among the five selected countries, partially because the analysis is based on a database consisting of journals

Table 1-1-69. Recent science and technology trends

1985	Japan's participation in Space Station Project Launching of EURECA Plan
1986	Japan becoming No.3 after the U.S., the U.K. in producing papers Japan becoming the leader in High-tech product exports
1987	Launching of HFSP Rapid increase in Japanese companies' R&D facilities abroad 5 Japanese companies among top 6 companies in patent registrations in the U.S. Beginning the doubling of the NSF budget in the U S Programs stating in Japan to invite foreign researchers (STA fellowship, etc.)
1988	Japan's R&D expenditures exceed Y10 trillion Japan-U S Science & Technology Cooperation Agreement concluded
1989	Japan's R&D expenditures as a percentage of GNP become the world's highest Japan's technology trade balance reaches equilibrium
1990	The U.S. proposes SSC Project Virtual agreement on engineering design activities of ITER

Source: Science and Technology Agency

mainly written in English, and partially because the ratio of Japanese researchers belonging to private companies is high.

Now let us turn our eyes to technology. As for technology trade, only the US enjoys a trade surplus. Japan registered a near equilibrium of exports and imports in FY1989. In 1980, the amount of Japan's exports of high-tech products became the largest in the world. The number of Japanese patent applications/registrations in the US is second only behind the US. In recent years, especially since around 1987, Japanese companies have begun to establish R&D facilities overseas, to develop products to meet local needs, and to conduct basic research based on long-term strategies (Table 1-1-69).

Figure 1-1-70 describes characteristics of scientific and technological activities in certain developed countries. The left part of each figure indicates activities by private companies: expenditures for research activities by private companies, number of overseas patent registrations, amount of technology trade exports, amount of high-tech products exported. The right part relates to the public sector; government expenditures for R&D, number of Nobel prize laureates, number of internationally co-authored papers, and number of papers cited by other countries' papers. It can be seen from the diagrams that the right and left parts almost balance for the US and European countries, but that Japan's figure is unbalanced. It can be said that Japan possesses significant capability in applied technologies supported by vigorous activities of private companies. However, the level of Japan's basic research activities is still low, as represented by this unbalanced picture compared with the pictures shown for other developed countries.

1.1.4.3. Expectations of Japanese Public Research Organizations

As described above, although the level of Japan's basic research activities vis-a-vis the US and Europe has risen to some extent, and Japan's technological level has become very high, there is an opinion that Japan has not been contributing to the world in proportion to Japan's level of technology. What does this mean? From abroad, Japan is seen to be receiving but not providing science and technology information, and relying greatly on overseas intellectual activities. It seems in Japan that the opportunities and the environment are not well-suited for foreign researchers and it has not established a system for disseminating science and technology information overseas. If this situation continues, Japan's imbalances with other countries will not be diminished and Japan will be criticized more seriously as not fulfilling its obligations. Frustration by people in other countries could eventually lead to Japan's isolation within the global community.

Looking at the world situation, the whole world has been facing issues which need international cooperation to solve, such as global environmental problems, widening gaps between the North and the South, and the issues of food and energy supply. Mega-science projects such as the space station and nuclear fusion activities require involvement by countries with a high level of intellectual and technological assets.

In order to cope with these issues, it is essential to strengthen and expand R&D activities in basic research in Japan's national research institutes, universities, and other public research organizations. Also, it will be necessary to disseminate science and technology information overseas and to deal with mega-science projects and global issues with sound judgment.

There are a number of challenges Japan faces in science and technology activities both inside and outside the country. The next chapter discusses how we should cope with these issues.

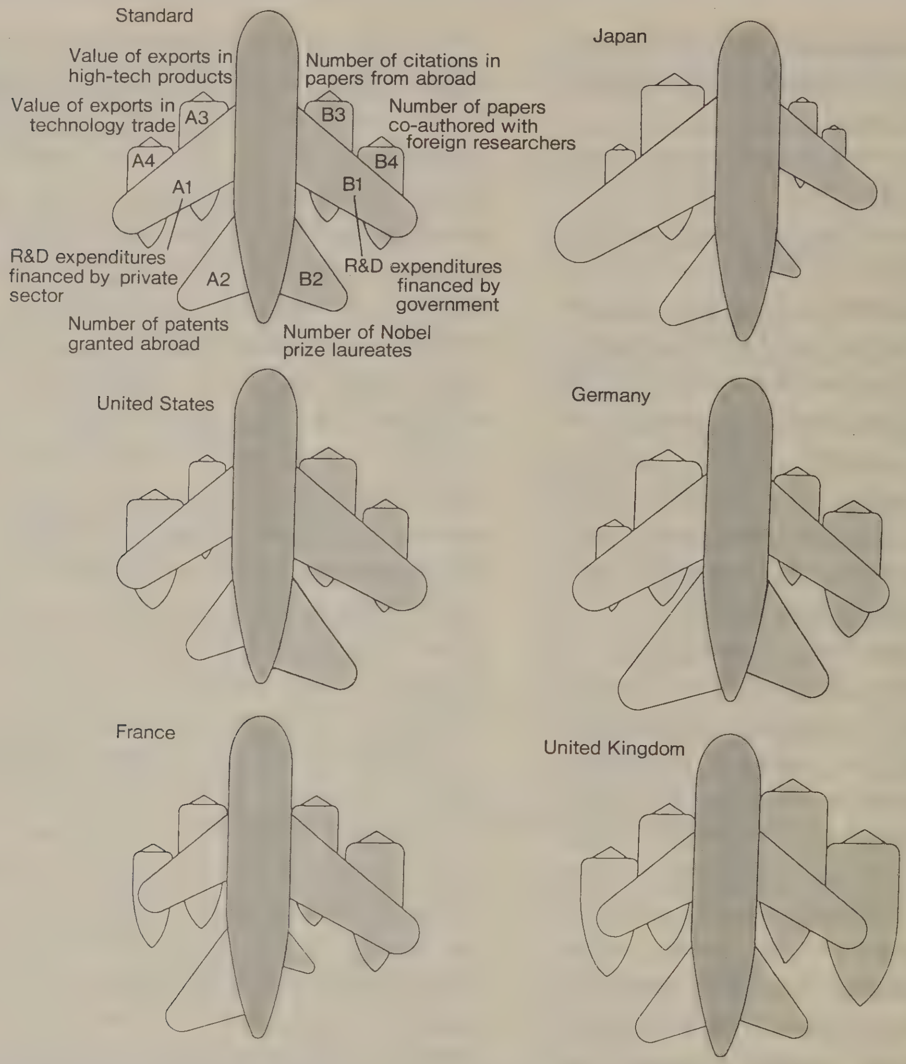


Figure 1-1-70. Comparison of science and technology activities in selected countries

Notes: 1. Each figure indicates relevant countries' scales in science and technology activities compared with its national power (GNP).
(The "Standard" figure indicates the normal form (in area) when a country's ratio of science and technology activities is equal to its gross national product.)
2. A1: R&D expenditures finance by private sector (1989)
A2: Number of patents granted abroad (1987)
A3: Value of exports in high-tech products (1986)
A4: Value of exports in technology trade (1988)
B1: R&D expenditures financed by government (1989)
B2: Number of Nobel prize laureates (1981～1990)
B3: Number of citations (1984～86) in papers (published during 1981～86) from abroad
B4: Number of papers co-authored with foreign researchers (1981～85)

Sources: A1: Each country's statistics
A2: Japan Patent Agency: "Patent Agency Yearbook,1989"
A3: U.S. national Science Board: "Science & Engineering Indicators 1989"
A4: Each country's statistics
B1: Each country's statistics
B3: Computer Horizons, Inc.: "Science & Engineering Indicators Literature Data Base"
B4: Computer Horizons, Inc.: "Science & Engineering Indicators Literature Data Base"

1.2. Promotion of Globalization in Scientific and Technological Activities

Progress in globalization of scientific and technological activities has brought forth increased opportunities for researchers' exchange, encouraging creation of new scientific ideas and technology through encountering of different ways of thinking. Scientific knowledge and technology have come to be used in various countries as common intellectual property which contribute to development of the world community through improvement of standards of life and economic growth. It is also expected that fruits of scientific and technological activities will help people solve large-scale issues facing mankind, such as those related to the global environment.

Widening horizons of scientific and technological activities has brought up cases in which scientific and technological activities and policies of one country affect other countries. It is thus essential that each country take precautions so that differences in recognition and responses between countries do not cause misunderstandings and tensions, or hinder international cooperation.

The basis of international relationships is to foster confidence between countries. International cooperation in scientific and technological activities can be established on such good relationships. Japan needs to meet a number of requirements for this purpose.

This chapter examines the basic idea for Japan to promote globalization of scientific and technological activities, and the challenges Japan faces, such as formation of intellectual stock which should be utilized as international public assets. Also, this chapter discusses a common set of values and rules which all countries should respect in supporting globalization of scientific and technological activities.

1.2.1. Basic Idea for Promoting Globalization

Globalization of scientific and technological activities examined in the previous chapter poses challenges with which the whole world should cope jointly, for the following reasons;

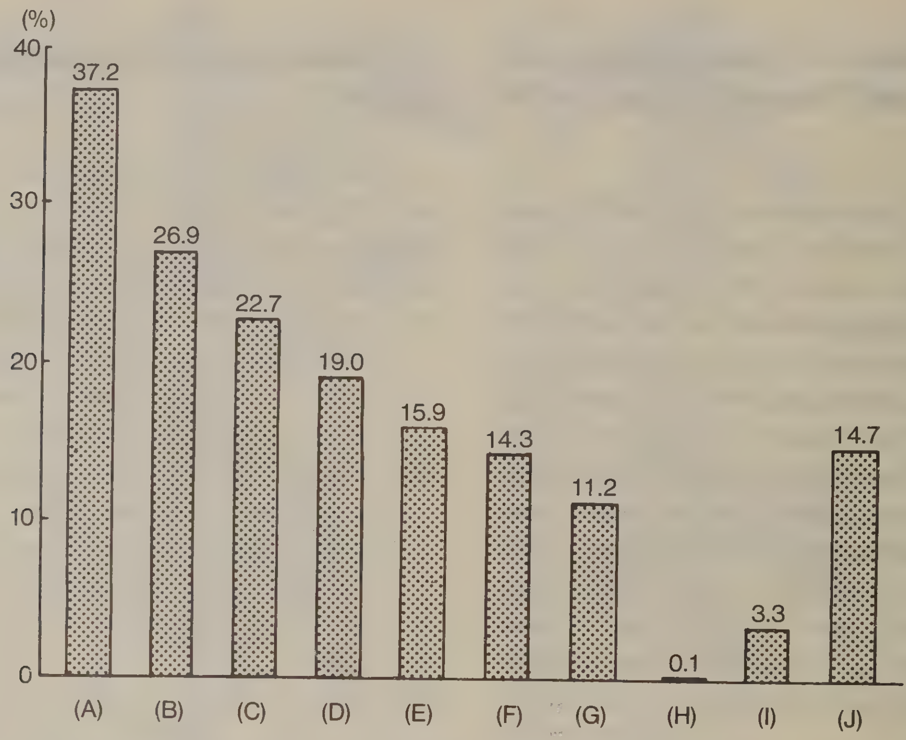
i) Basic research is an area where individual researchers display their creativity, and the results should be shared by many people as common intellectual property.

ii) While there have been movements toward excessively protecting rights of inventors, some aspects of technology should be international public assets and should be effectively utilized for well-being of mankind.

iii) Joint international efforts will be necessary to solve problems which affect the co-existence of mankind and the earth, or for managing large-scale scientific and technological activities which require broad cooperation.

Japan has been relying much on the achievements obtained in the US and European countries for the basis of its technology development. However, after this, Japan should take the initiative to promote globalization of scientific and technological activities, even if there should be a tendency somewhere in the world to give excessive protection to their own technological property.

In the "Opinion Poll on Economic Structure Adjustment" conducted by the Prime Minister's Office in September 1988, there was a question, "What step can Japan take to fulfill its responsibility to contribute to the world economy, in proportion to its position in the international society?" 37% or the largest group of the respondents replied: "Dispatch and acceptance of experts and engineers", followed by 27% of respondents replying: "Cooperation in the fields of science and technology" (Figure 1- 2-1). It is thus commonly felt that Japan needs to



(A) Dispatch and acceptance of experts and engineers
(B) Cooperation in the fields of science and technology
(C) Cooperation with activities of international organizations
(D) Opening market and expanding imports
(E) Promotion of overseas production and service activities
(F) Loans by the govemment and private businesses
(G) Provision of funds and equipment
(H) Others
(I) Nothing especially
(J) Don't know

Figure 1-2-1. How Japan should contribute to the world economy

Note: Multiple responses
Source: Prime Minister's Office: "Opinion Poll on Economic Structure Adjustment (Sep. 1988)"

encourage domestic R&D activities and to contribute to formation of mankind's greater intellectual stock. Japan should at the same time help establish the basic foundation which stimulates different countries to establish their policies based on commonly available information and recognition, and promotes R&D activities under a common framework.

1.2.2. Characteristics of International Cooperation in the US and Europe

People throughout the world have come to realize more than in the past that science and technology are the basis of national power, and governments have been taking various measures to strengthen science and technology policies.

The US has been accepting a number of researchers and students from different areas of

the world, and has contributed greatly to development of science and technology for mankind. The US is thus the biggest R&D center in the world, and has an abundance of human and monetary resources for research activities, as exemplified by large number of research papers published and cited. The US used to promote huge projects such as the Apollo Project independently. However, in recent years, due to financial difficulties, the US have come to solicit cooperation from other governments in large projects such as the space station, superconducting super collider, nuclear fusion, etc. explaining that their benefits may be shared by the world or participating countries. Reflecting weakening competitiveness of the US manufacturing industries, the US government also has been taking policies to strengthen the protection of intellectual property rights and national security.

In Europe, countries are adjacent to each other, and have a common cultural background. The scale of their R&D activities is not as large as in the US. These factors made them more apt to cooperate with each other, as exemplified by the large number of citations of papers written in other countries, and the large percentage of co-authored papers. In the domain of large-scale research projects, European countries are collaborating for example in nuclear physics research, space development, etc. Furthermore, to streng then competitiveness of private companies in Europe, the Framework Program (EC) and of private companies EUREKA programs (led mainly by EC member countries) were launched in the mid-80s. The establishment of a single market by the end of 1992 will encourage further flows of personnel and funds which will result in further development of science and technology within Europe. A concern is that if these countries go too far in the direction of regionalism, communication between Europe and the rest of the world will be discouraged, impacting negatively on the development of international science and technology. Future trends in EC thus should be carefully watched.

1.2.3. Towards "Internal Globalization"

The circumstances of Japanese science and technology activities are significantly different from the US and Europe in geographical and historical terms. Japan is located far away from the world centers of science and technology -- a disadvantage in communication. Historically, Japan was a late starter, and worked hard to catch up with the level of the US and Europe, which made Japanese people concentrate more on development of technology, without implementing sufficient activities in basic research. But now science and technology activities in Japan have become world class, and Japan is expected to contribute to the whole world in many fields.

While we have witnessed progress in globaliza-

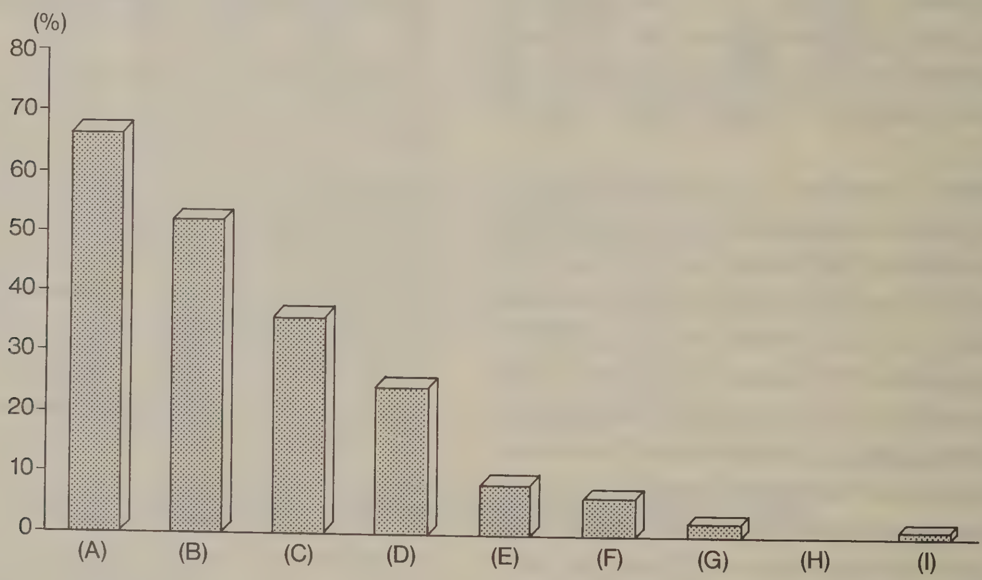
Table 1-2-2. Phases of globalization of science and technology activities

Phase 1	Exchange of information, data, samples and personnel
Phase 2	Increases in international joint research and co-authorship of literature
Phase 3	Existence of R&D centers which provide "cutting edge" information to the world; Operation of megascience projects in Japan

Compilation: Science and Technology Agency

tion of Japan's science and technology activities, as shown in Chapter 1, we are still only at the beginning (Table 1-2-2).

An important challenge for Japan is to create first class R&D results in basic research. These provide the common basis for survival and development of humanity at large. In the OECD's Technology Economy Program, each government is asked to support domestic efforts in basic research activities. In the Survey of High-tech Researchers and Engineers, FY1991, 66% of responding researchers replied that Japan's role in contributing to international society is: "accumulation of intellectual property with further expansion of basic research in Japan" (Figure 1-2-3). If Japan keeps absorbing information from outside and does not provide as much, in spite of its raised level of scientific and technological activities, Japan's activity pattern will look like odd and co-existence and co-prosperity with other countries will be endangered. In order for Japan to become one of centers of R&D activities where people from different parts of the world gather and work and produce successful results, it is essential to improve the basis for R&D activities in Japan, and take measures to increase the intellectual stock such as achievements in basic research



(A) Accumulation of intellectual property with further expansion of basic research in Japan
(B) Promotion of international research cooperation
(C) Increase of researcher and engineer exchanges between Japan and developing countries
(D) Increase of researcher exchanges between Japan and developed countries
(E) Establishment of research institutes (facilities) in foreign countries
(F) Transfer of private corporate technologies to foreign countries
(G) Financing overseas megascience projects
(H) Present activities are already sufficient
(I) Others

Figure 1-2-3. International role of Japan in the field of science and technology

Note: Multiple responses
Source: Science and Technology Agency: "Survey of High-tech Researchers and Engineers (FY1991)"

which are usable as international public assets, or generic technology which can be applied in various fields.

For this purpose, it is necessary to increase research funds and develop excellent leaders and successors for research activities at public research organizations. Improvement of the research environment for such activities also is indispensable. Along with these efforts, measures should be taken to accept more foreign researchers, and to improve related conditions, as well as to promote information exchange and cooperation with developing countries.

Japan's private corporations conduct a large part of R&D activities in this country. Private companies are required to move toward more active basic research activities, and treat the resultant achievements possibly as public assets. Corporate management of research activities should become compatible with those common in other countries. It is also necessary to encourage the smooth establishment of R&D facilities by foreign businesses in Japan.

In order to enrich basic research in Japan, it is necessary to improve the research environments -- including funds, human resources, facilities and support systems--to match the world level, and make Japan a genuine member of the world R&D network. Such process will move the country a way toward "internal globalization".

1.2.3.1. Formation of Intellectual Stock as International Public Assets

In order to make Japan a place to conduct first class basic research activities, it is necessary to improve the level of research activities, and to form intellectual stock, centering to successful results of basic research, which can be used effectively as international public assets. For this purpose, it is essential to improve basic research activities at national research institutes, universities and colleges.

1.2.3.1.1. Expansion of Research Funds

While Japan's investment in research and

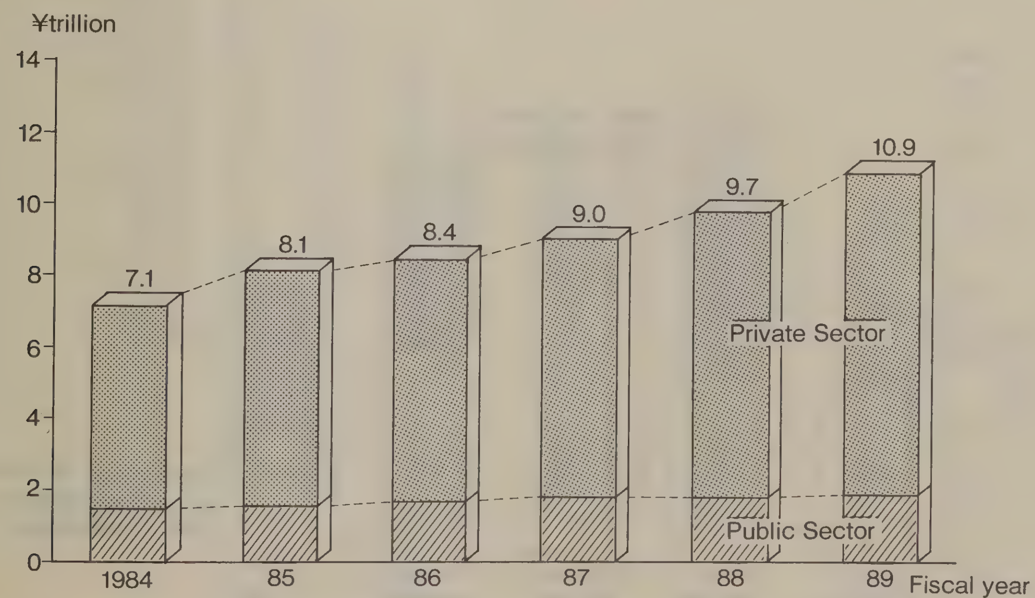


Figure 1-2-4. R&D expenditures by source of funds

Source: Management and Coordination Agency, the Statistics Bureau: "Report on the Survey of Research and Development"

development has been increasing in both the government and private sectors, the growth in the private sector is large, leaving the percentage of the government funds small (Figure 1-2-4). While what is considered basic research shown in the statistical figures may differ in each country, the ratio of public sector research is low in Japan compared with than in other major countries (Figure 1-2-5). For example, Japan's expenditure for basic research is 45% of that of the US. However, regarding the expenditures of government research organizations and universities/colleges, where the results of research activities are accessible from outside, the amounts Japan spends account for 34% of the expenditures in the US. This indicates that financial support for basic research in the public sector is small in Japan (Figure 1-2-6). It is necessary for Japan to expand government investments into research activities, in order to strengthen the foundation in basic research activities and to form larger assets of intellectual stock.

1.2.3.1.2. Mecca for Basic Research

In order to improve basic research activities in Japan, the environment for research activities at national research institutes and universities should be made good enough to attract researchers from various countries and to produce excellent results. These institutions should aspire to be world's "Mecca" for basic research.

Elements of research institutes which attract excellent researchers worldwide would be: world class research authorities and leaders, collection of the latest information on science and technology, unique research and experiment facilities, or remarkable research activity output (Figure 1-2-7). Researchers in Japan think such research institutes exist abroad, but that few exist in Japan. It is our challenge to increase those institutions which meet these requirements in Japan.

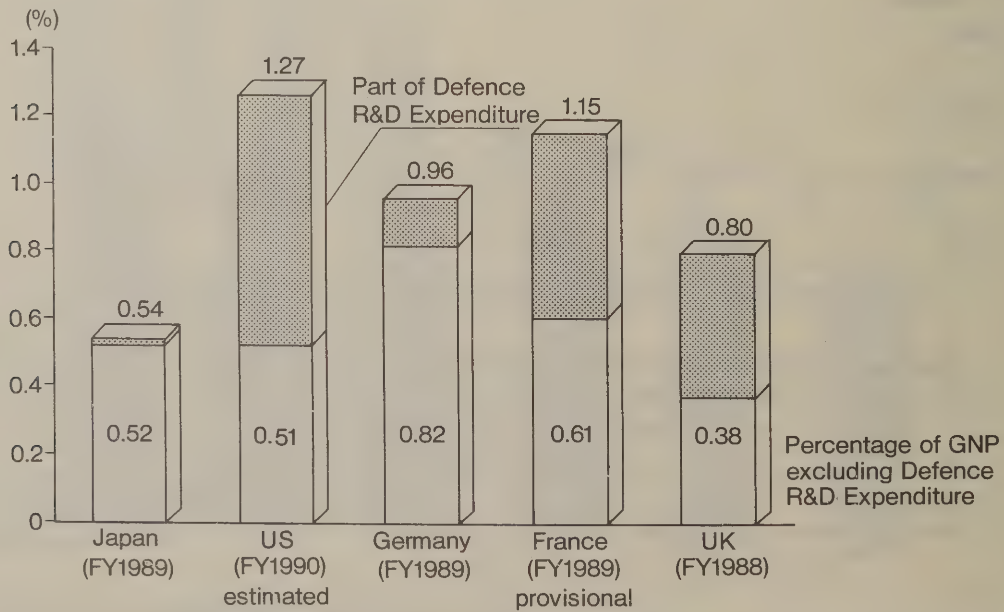


Figure 1-2-5. R&D expenditures financed by government as a percentage of GNP

Source: Statistics of relevant nations, compiled by Science and Technology Agency

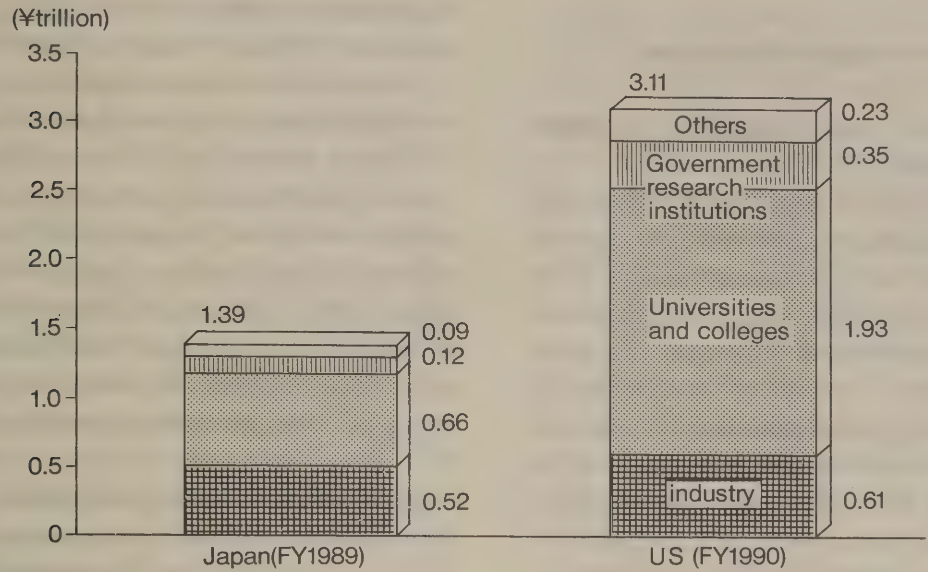


Figure 1-2-6. Comparison of basic R&D expenditures between Japan and the US

Note: The data for Japan is for natural sciences only
Source: Japan; Management and Coordination Agency, the Statistics Bureau: "Report on the Survey of Research and Development" U.S. ; "National Patterns of R&D Resources: 1990"

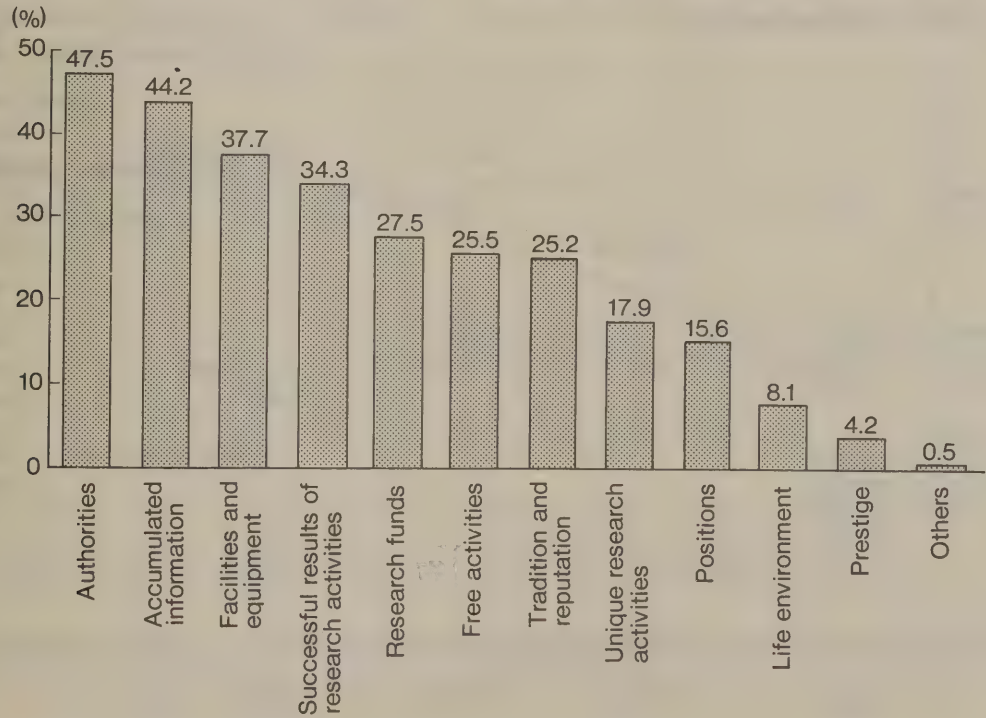


Figure 1-2-7. Factors making research institutes attractive to world researchers

Note: Multiple responses
Source: "Survey on Research Management Improvement for Promotion of Basic Research in Japan", conducted by the Japan Techno-economics Society, for STA. (Mar. 1989)

1.2.3.2. Need for Human Resources

1.2.3.2.1. Human Resources at National Research Institutes

Human resources are important for promoting basic research activities. The number of Japanese researchers have been increasing steadily in the past several years, but this is mainly attributable to the growth of research personnel in private companies. The increase of researchers at universities/colleges has been slow. At national research institutes, the number of researchers has remained level. It is now important to secure qualified research force there (Figure 2-2-4,7).

The number of researchers working at government research institutes internationally in Japan is 27,006 in 1990, an increase of 3% in the past ten years. In the US, it has increased by 15%, and numbered 65,800 in 1988. In Germany, the number increased about 20%, to 20,574 people in 1987, and France enjoyed an increase of more than 1.7 times, numbering 22,200 in 1987 (OECD statistics). In Japan, it is important to increase the research force at these national research institutes in order to improve basic research activities. The number of researchers at universities and colleges has been increasing reflecting the fact that new universities/colleges or departments have been established in recent years. Yet the research force should be still expanded to improve basic research there.

1.2.3.2.2. Future Human Resources

In order to improve basic research activities in Japan in the future, it is essential to secure qualified researchers. This is the case not only at national research institutions but also at universities, and private businesses which are supposed to play a greater role in basic research

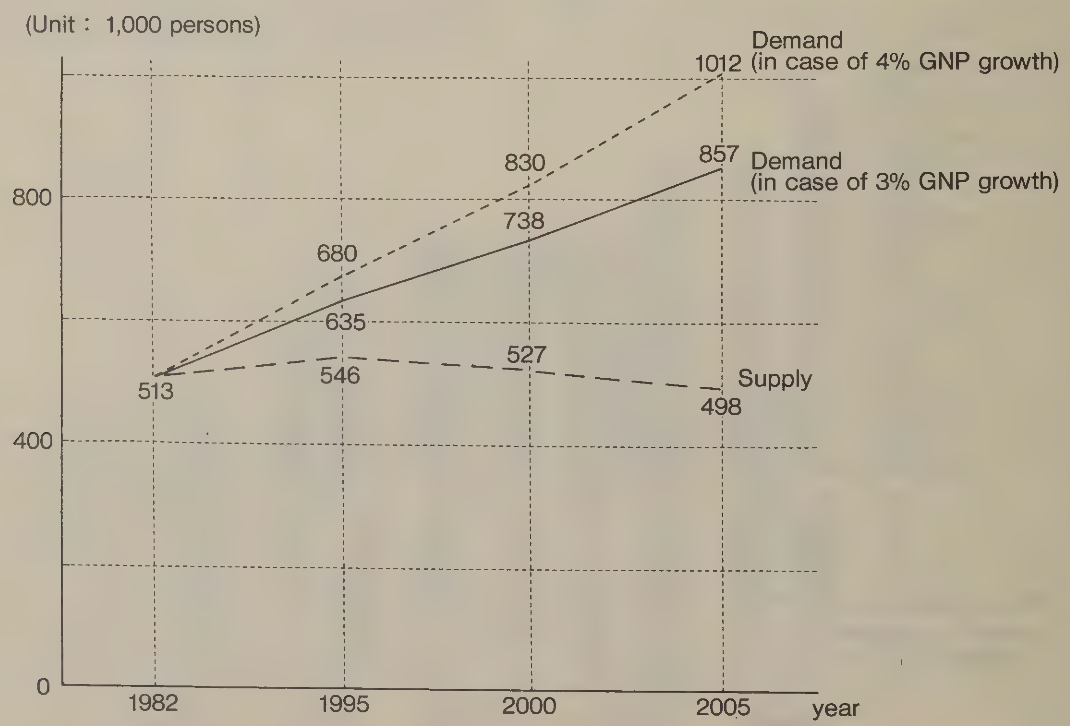


Figure I-2-8. Estimated number of researchers in the future

Source: "Survey on Research Personnel for Promotion of Basic and Leading Science and Technology" conducted by the Institute for Future Technology, for STA (Mar. 1990)

activities. The demand for researchers is taken here as a function of real GNP, and supply as function of working age population, in order to estimate the future demand/supply of researchers based on the past history. In the year 2005, demand will exceed supply significantly, i.e., if real GNP increases at an annual growth of 3%, the excess of demand over supply will be about 360,000 and if real GNP grows at 4%, the gap will be about 510,000 (Figure 1-2-8). This model may be too simplistic to forecast exactly the future demand/supply situation, and there may be a number of other factors which would affect the future trends. However, at least this estimate indicates that securing research personnel will be an important issue in the future.

Another concern is the tendency of young people not to major in science and technology at universities and colleges. It is anticipated that the 18 year old population will be smaller in the future, and consequently, high school graduates taking science and technology courses in higher education will continue to decrease. Assuming that the rate of applicant to engineering and physical sciences departments against the total population of 18-year-olds in 1989 is maintained in the future, it is anticipated that in the year 2000, applicants to engineering departments will decrease to 89,000 and those to physical sciences ca. 11,000 (Figure 1-2-9). The number of Japan's young people is estimated to decrease more drastically than the US and Europe in the early 21st century. If no effective measures are taken to keep young people interested in science and technology, Japan will face serious difficulty in keeping its science and technology level high in the future.

To attract people to science and technology fields, improvements in personnel administration, such as salaries, and better research environments will be essential. Besides, it will be important to improve the image of science and technology to keep young people interested in scientific and technological studies. The pleasure

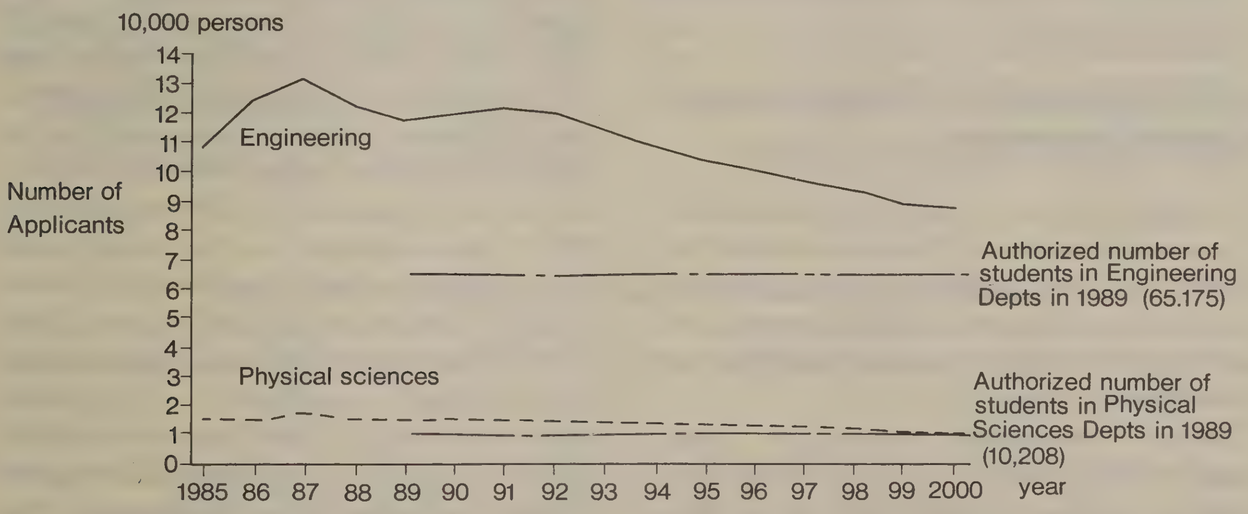


Figure 1-2-9. Estimated number of applicants to departments of engineering and physical sciences in the future

Note: Figures obtained on an assumption that the ratio of applicants to Engineering and Physical Sciences Departments among the total population of 18- year olds remains the same.

Source: NISTEP: "Choice of University Applicants among Fields of study: How many young people in Japan are planning to study science and engineering in universities ? (August 1990)"

and sensation which only scientists and engineers can enjoy at the moment of the discovery or invention should be handed down to the next generation.

From the standpoint of encouraging high quality researchers, more flexibility in assignments, and excellent and improved research environments which allow creative activities by each individual researcher will be necessary. Qualitative and quantitative expansion of graduate schools also is needed.

Measures also should be taken to provide women, senior citizens and foreigners with job possibilities. Women may be disadvantaged by marriage, child care and other factors which tend to discourage their involvement in research activities.

As for senior citizens, those who have abilities and also willingness to work should be provided with job possibilities and with regard to foreigners it may be a future task for us to reorganize our social structure as a whole so that it can function smoothly even with foreigners incorporated into it.

1.2.3.3. Improvement of Research Infrastructure and Environment

In order to improve basic research activities, it is essential to enlarge the space available for research activities, improve research equipment and facilities, and increase assistants and support staff in the national research institutes and universities/colleges.

Foreign researchers working in Japan complain that research facilities of national research institutes and university/colleges have little technical support, limited funds, poor test equipment, and old and unclean laboratories.

In the "Survey of High-tech Researchers and Engineers", among the respondents who had worked in laboratories and institutions in the US and European countries, 60% of researchers at national research institutes, 80% of those at universities and colleges, and 74% at private companies replied that the US and Europe are better in terms of the space available for research activities. As for "sufficiency of experimental equipment", those who replied that "conditions in the US and Europe are superior" are 16% of those working at national research institutes, 23% of those at private companies, but 51% of those working at universities and colleges. Only 8% replied that conditions in Japan are superior. As for "maintenance of experimental equipment", 34% of those working at private companies replied that the situation in the US and Europe is superior, but 34%, almost the same percentage, replied that Japan is superior. However, 67% of those working at national research institutes and 74% of those at universities/colleges replied that the situation in the US/Europe is superior to Japan. Regarding the "number and ability of assistants", 92% of those working at national research institutes and 88% of those at universities/colleges replied that the US/Europe are superior; 52% of those at private companies replied that the US/Europe is superior, and 15% said that Japan is superior. While most of the respondents replied that the "social status of researchers" is superior in the US/Europe, 40% of those working at universities/colleges replied that the status is equal between Japan and the US/Europe. Almost 80% of the respondents on the whole replied that "evaluation of research activities is stricter in the US/Europe than in Japan' (Figure 1-2-10).

The Science Council of Japan surveyed: "Environmental conditions on scientific research activities in Japan 'from the scientist's survey' (April 1991)". Respondents were asked whether they agreed with the statement: "The work space for your research group is appropriate for current research activities". A total 66% of the respondents replied, "Don't agree at all" or "Hardly agree". To another statement: "The number of assistants is appropriate for research activities", a total 76% replied "Don't agree at all" of "Hardly agree". Many replied that they face a high degree of inconvenience regarding

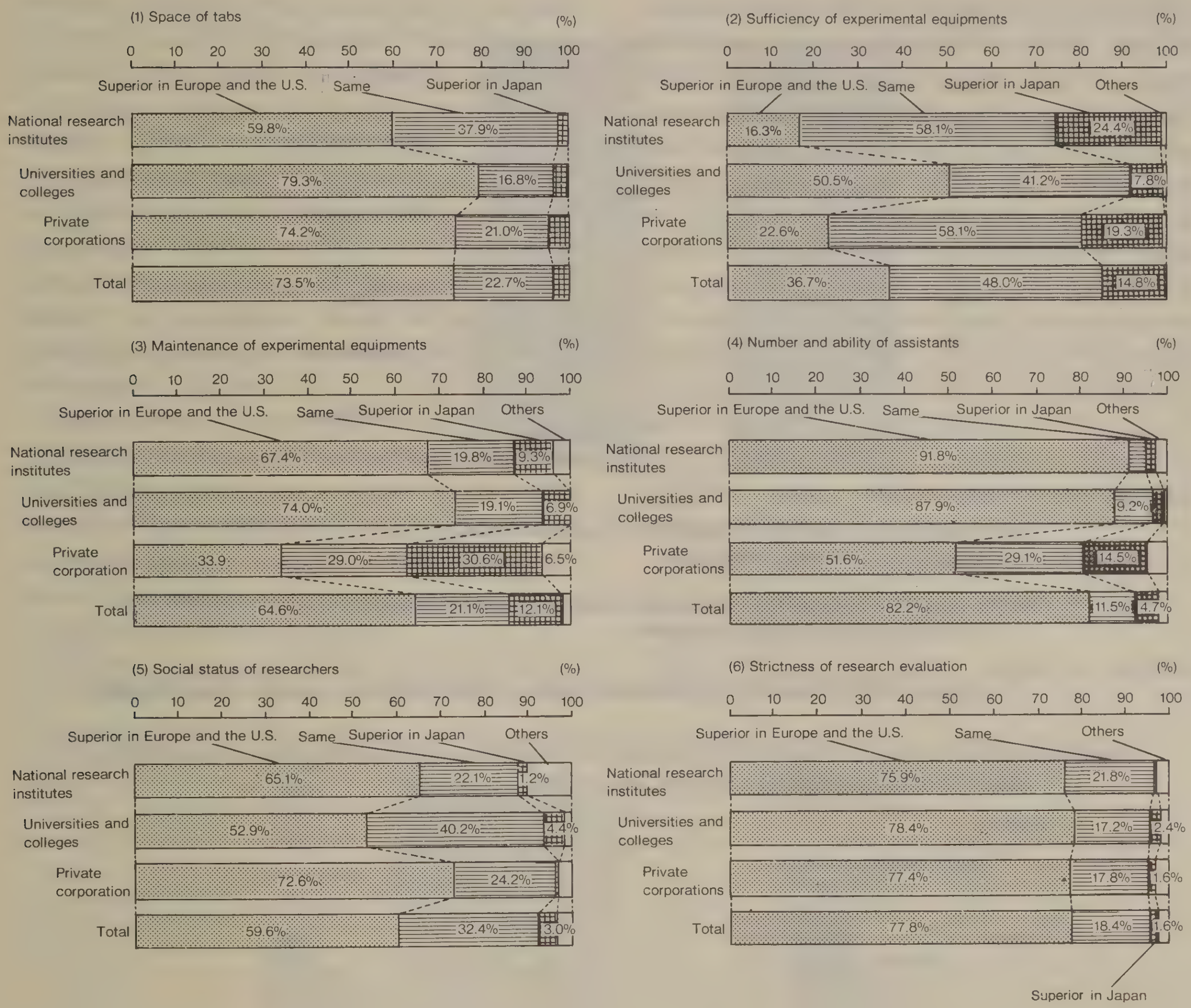


Figure 1-2-10. International comparison of research environments

Source: Science and Technology Agency: "Survey of High-tech Researchers and Engineers (FY1991)"

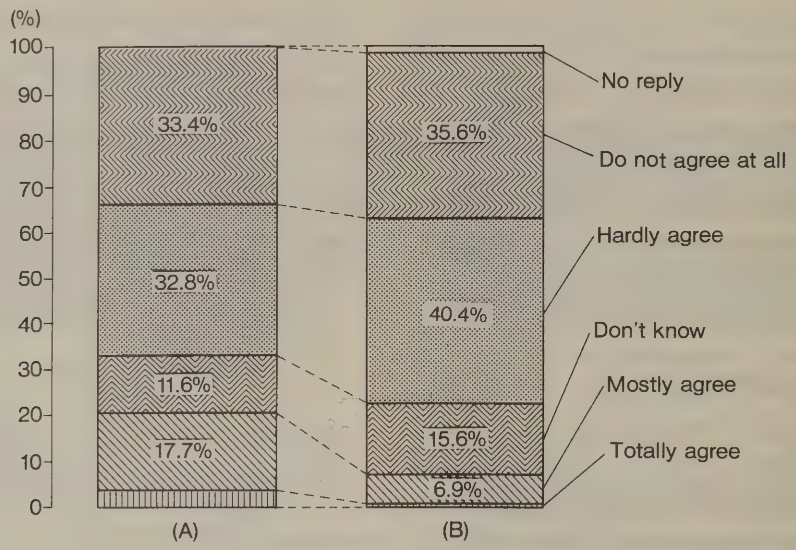
available space and assistants (Figure 1- 2-11). In fact, the number of assistants per researcher in Japan is extremely small compared with other major countries (Figure 1-2- 12).

As understood from these surveys, conditions of space and assistants at national research institutes and universities in Japan are poorer than those in the US and Europe. Conditions for research activities at these organizations and institutions need to be improved significantly to support better basic research activities in Japan.

1.2.3.4. Accepting More Foreign Researchers

1.2.3.4.1. Increasing in Number of Foreign Researchers

As for the exchange of researchers with other countries, the number of researchers going abroad from Japan is still much bigger than the



(A) The laboratory space for the research group is appropriate, and there is no inconvenience in carrying current research activities.

(B) The number of assistants at the research institute is appropriate, and there is no inconvenience in carrying out current research activities.

Figure 1-2-11. Research environment (space of laboratory, number of assistants)

Source: Science Council of Japan: Environmental conditions on scientific research activities in Japan "from the scientist's survey" (Apr. 1991)

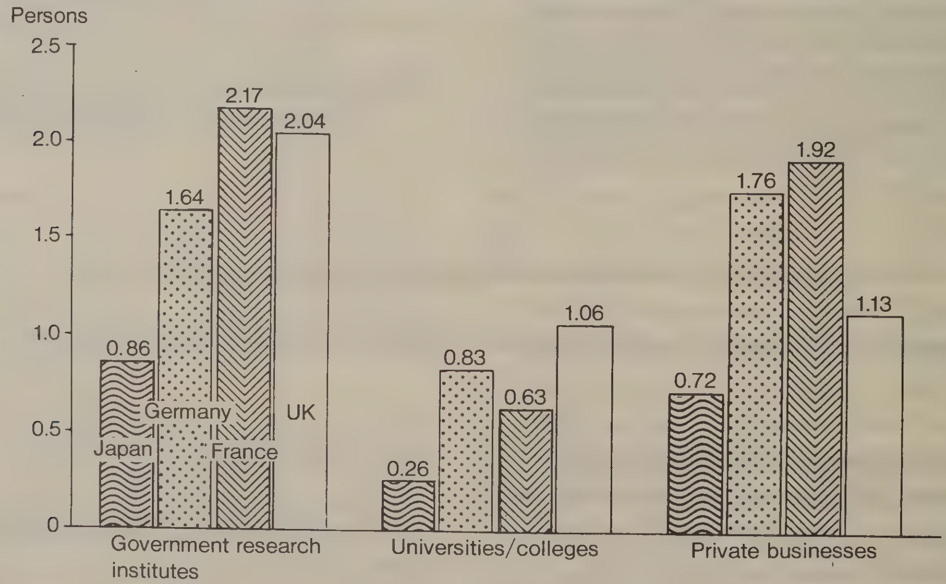


Figure 1-2-12. Number of assistants per researcher (1987)

Note: Figure for Japan is not on a full-time equivalent basis. Assistants in humanities/social sciences are included.
Compilation: Science and Technology Agency
Source: OECD Statistics

number of foreign researchers accepted by Japan. A large number of Japanese researchers go mainly to developed countries such as the US, while those coming to Japan are mostly from Korea, China and other Asian countries. Acceptance of researchers who have different cultural and historical backgrounds and different ideas from Japanese is important to promote research and development. Measures must be taken to encourage such exchanges of researchers, especially the acceptance of foreign researchers in Japan.

Almost 90% of researchers welcome foreign researchers in Japan as their colleagues (Figure 1-2-13). Japanese researchers expect that working with foreign researchers will give them incentives in their research, and help strengthen closer relationships with these foreigners' home organizations (Figure 1- 2-14).

For this purpose, the Law for Facilitating Government Research Exchange was enacted, so that researchers of other countries can be employed as high as research division managers or research section managers at national research institutes. But this law has not yet been put into practice effectively. While the government established new fellowship systems in recent years, the scope of these systems are still small compared with similar systems in the US and Germany which are designed to accept large numbers of researchers from other countries. Exchanges of researchers across national borders should be promoted much more.

1.2.3.4.2. Better Infrastructure for Foreign Researchers Living in Japan

In order to encourage foreign researchers to work in Japan, it is also necessary to improve their living environment.

According to the survey regarding obstacles

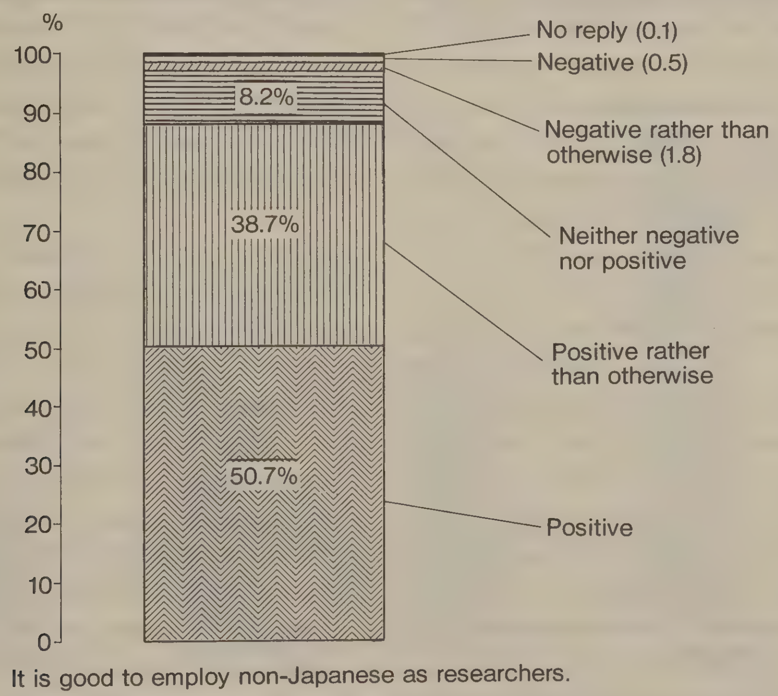
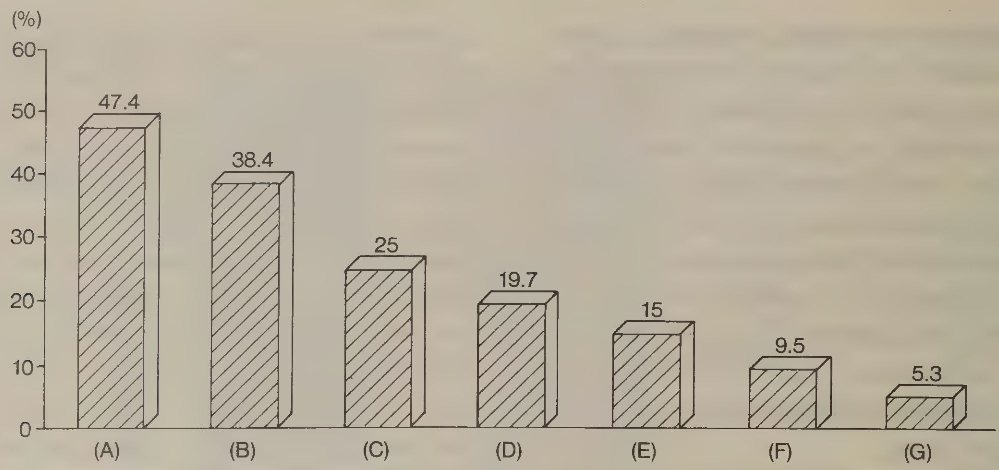


Figure 1-2-13. Employment of non-Japanese researchers

Source: Science Council of Japan: "Environmental conditions on scientific research activities in Japan — from the scientist's survey — (Apr. 1991)"



(A) Good incentive for Japanese researchers
(B) Closer relationship with the visiting researcher's home organization
(C) Foreign researchers obtain successful results
(D) Effective to meet the shortage of research manpower
(E) No specific advantage
(F) Better image of institute or organization
(G) Others

Figure 1-2-14. Advantages in accepting foreign researchers

Note: Multiple responses
Source: Science and Technology Agency: "Survey of High-tech Researchers and Engineers (FY1991)"

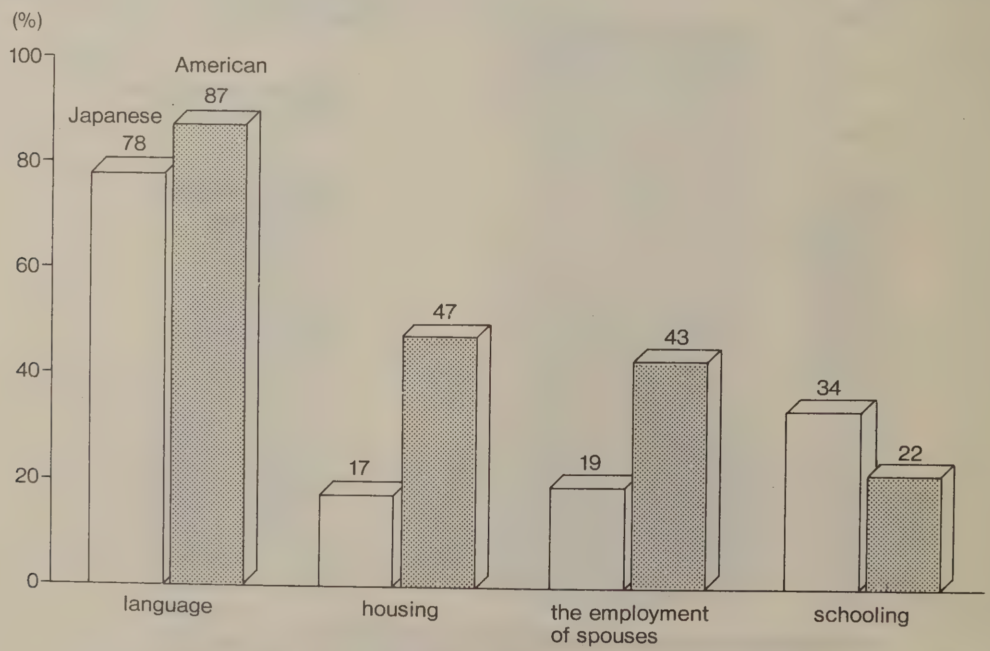


Figure 1-2-15. The most significant barriers on doing research in Japan/US.

Note: Multiple responses
Source: Data on "the Task Force on Access" established under "The Japan-US Science and Technology Cooperation Agreement"

for researchers to work outside their home countries, both Japanese and American researchers replied that "language" is the most significant barrier. Then, Americans replied that "housing", "employment of spouse" and "education of children" were their major issues, in this order. Japanese researchers working abroad had the same concerns: "education of children", followed by "employment of spouse" and "housing" (Figure 1-2-15).

Forty percent of foreign researchers conducting research in Japan did not bring their spouses because "the spouse has his/her own job back home", in most cases (Figure 1-2-16). Thirty-three percent of the researchers left their children home mostly for "educational needs" (Figure 1-2-17).

Thus, issues other than research activity itself, e.g. housing, employment of the spouse, and children's education, can become sources of difficulties for foreign researchers working in Japan. While housing problems could be solved by increasing financial allowances, issues relevant to spouse's employment and children's education need to be addressed comprehensively. Therefore, the most important issue is how far this kind of infrastructure will be established in near future.

There are some examples of the problems being alleviated: STA established in Matsushiro of Tsukuba City accommodations for foreign researchers working at national research institutes in Tsukuba Science City. The Tsukuba Center for Institutes is responsible for management and operation of these living facilities, and provides Japanese classes for foreign researchers and their families living in the City. The Research Development Corporation of Japan also operates in Takezono of Tsukuba City for foreign researchers and their families, as part of the Corporation's international research exchange programs. It also publishes an information booklet in English for living in Japan, and provides Japanese classes and counseling service in English. MITI's Agency of Industrial Science and Technology's International Research Exchange Center provides similar services.

Improvement of these services will become increasingly important in coming years.

1.2.3.5. Dissemination of Scientific and Technological Information

As mutual interdependence among countries increases, the importance of information exchange increases. Foreign demands for and dissatisfaction over Japanese information are increasing, so Japan is required to disseminate high quality information speedily to the world community. For this purpose, Japan should not only enlarge its databases, but also promote the international utilization and dissemination of literature which is not readily available. The Japanese language could be the biggest barrier to international dissemination of Japanese information. It thus has become one of our biggest challenges to develop an effective machine translation system which will enable English translation of huge volumes of materials written originally in Japanese. Also, our reprographic rights clearance system must be improved so that use of Japanese scientific and technological information will be facilitated overseas.

1.2.3.5.1. Collection of Japanese Information in the US/Europe

As Japan's position in the fields of science and technology has risen, various countries have become more interested in scientific and technological information from Japan. In the US, the need to collect more information on scientific and technological activities in Japan has been known since the 1970s. In accordance with the Japanese Technical Literature Act of 1986, the Office of Japanese Technical Literature was established in the US Department of Commerce. The Japan-US Science and Technology Cooperation Agreement of 1988 also calls for more active exchange of scientific and

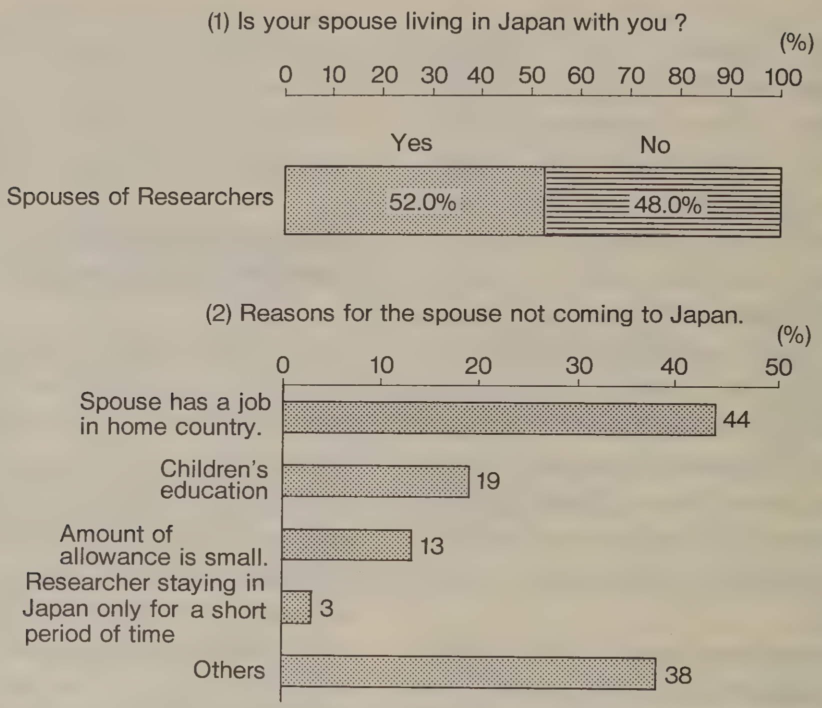


Figure 1-2-16. Spouses of researchers

Source: Tsukuba Expo '85 Memorial Foundation: "Survey on Life Environment of Foreign Researchers (Mar. 1991)"

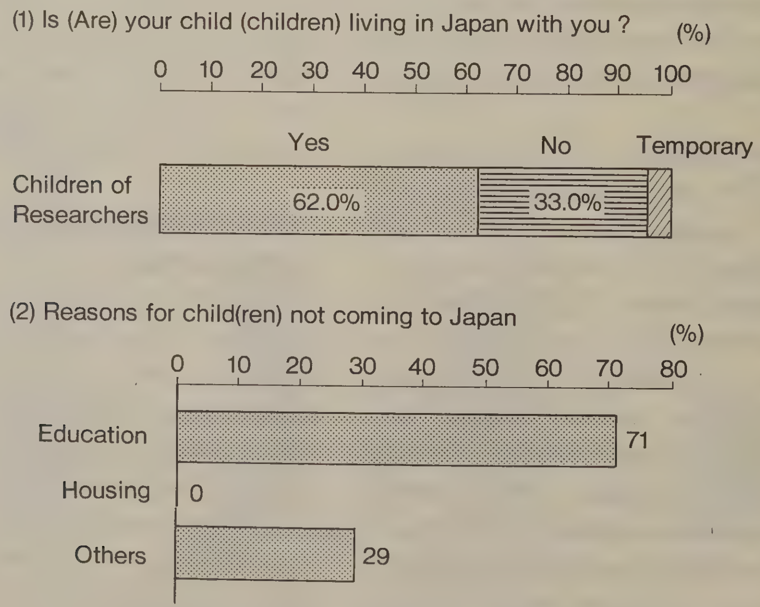


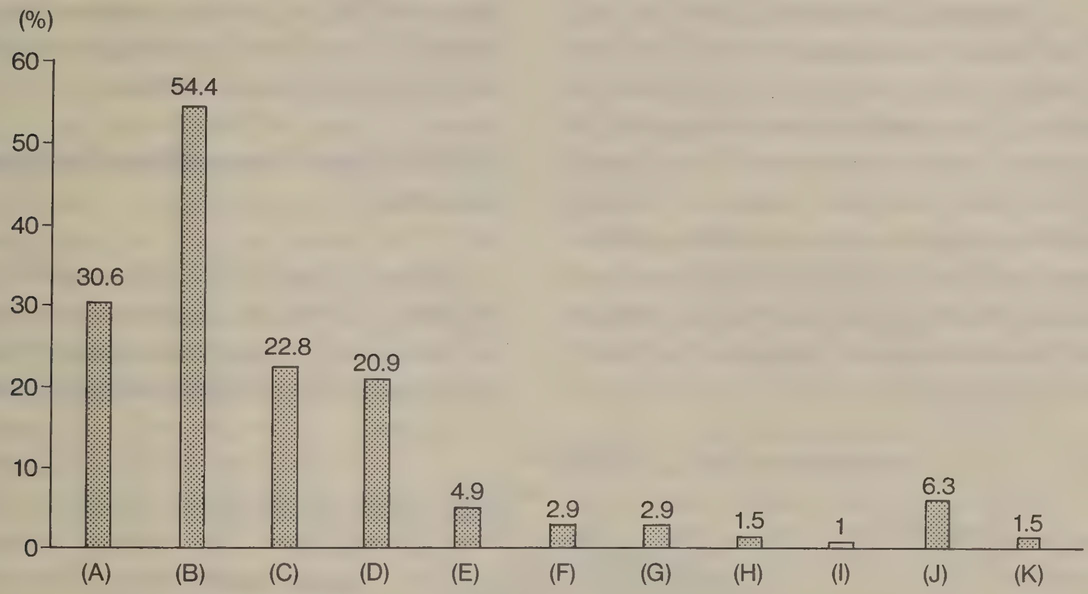
Figure 1-2-17. Children of researchers

Source: Tsukuba Science Expo '85 Memorial Foundation: "Survey on Life Environment of Foreign Researchers (Mar. 1991)"

technological information between the two countries. In 1986, the EC launched the Japan-Info Project, which encourages collection of Japanese information. International conferences by experts of information on Japan were held in 1987 and 1989, where methods of access to Japanese information were discussed.

While the above-mentioned efforts have been made, complaints are heard from overseas such as: "It is not clear what kind of information is available", or "Full texts are not easily obtainable". According to a survey conducted in the US in 1989, as few as only 5.4% of the respondents replied that they had used Japanese databases before. The prime reason for not using Japanese databases, besides "No need", was that "I/we do not know the appropriate Japanese database" (Figure 1-2-18).

It is thus necessary for Japan to promote dissemination of Japanese information on S&T overseas by increasing directory information in English, developing English, databases, and by



(A) No need
(B) I/we do not know the appropriate Japanese DB
(C) Limited number of original documents in English
(D) Limited availability of English abstracts
(E) Retrieval cost is expensive
(F) Communication cost is expensive
(G) Large time lag for new information
(H) Differences between Japanese and American identification systems cause complications
(I) Quantity of information in DB is not sufficient
(J) Others
(K) No response

Figure 1-2-18. Reasons for not using Japanese databases (DB)

Note: Multiple responses
Source: "Research on the Dissemination of Japanese Scientific and Technical information" conducted by Mitsubishi Research Institute, for STA (March 1989)

increasing the translation of original Japanese documents into English.

1.2.3.5.2. Improvement of Reprographic Right Clearance System

The Japan Reprographic Right Center (JRRC) is going to be established to mediate between rights holders and users of reproductions for collective clearance of copyrights. The "Japan Academic Societies System for Copyright Clearance" (dealing with natural sciences publications by academic societies) and the "Collective Reprographic Right Clearance Center of Authors & Publishers" (dealing with other publications) are already established, and have begun work on collective trusts of copyrights. These associations have agreed to grant licenses to users of reproductions through the JRRC, and have been preparing for the unification of these associations with the JRRC. It is expected that the JRRC will offer a more convenient procedure for copyrights clearance and that the distribution of Japanese information will be facilitated, too.

1.2.3.5.3. Information Distribution Network

Various computer networks are being used as means for information exchange between researchers. BITNET is one of them, using main-frame computers as nodes. Currently, the number of nodes throughout the world is 3,371, but the number of nodes within Japan is only 93, or less than 3% (Figure 1-2-19). The volume of information coming from the US into Japan is larger than that going out from Japan to the US. In order to make Japan one of major information centers of the world, it is necessary to strengthen the capability to provide information, and to expand science and technology information services from Japan to overseas.

1.2.3.6. Closer Cooperation with Developing Countries

Although Japan's ODA is the world's highest, the ratio of technical assistance is still small.

Developing countries, especially Asian/ Pacific nations, are using science and technology

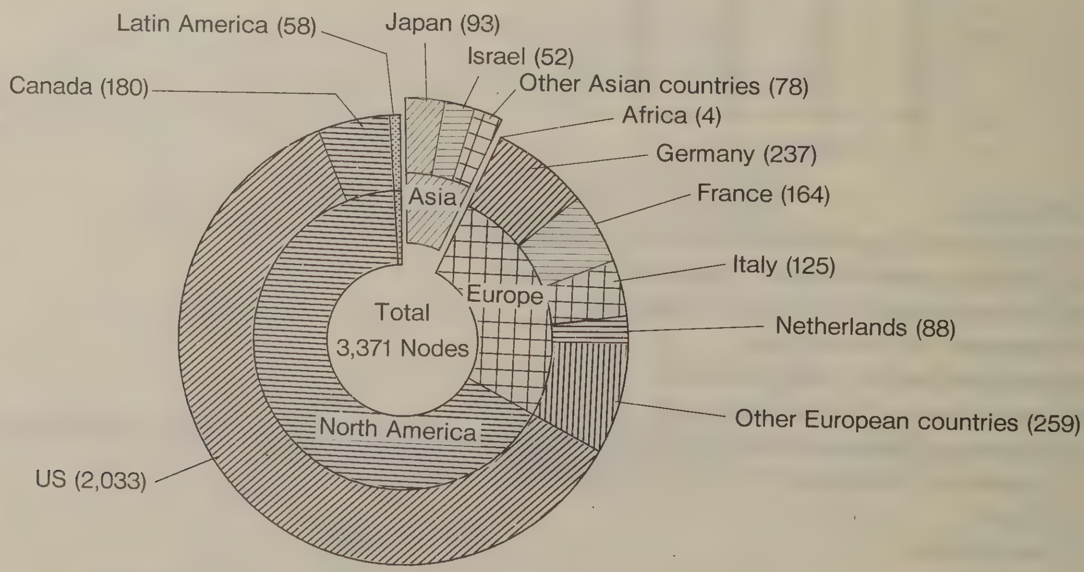


Figure 1-2-19. BITNET nodes (as of May 1990)

Source: Report on "Survey of International Tsukuba Network", conducted by Mitsui Information Development Corporation, for Science and Technology Agency (Feb. 1991)

to develop their national economies, and they have been expecting Japan to provide them assistance in this direction.

According to the "Survey of High-tech Researchers and Engineers", researchers feel Japan can play a better international role by "increasing exchanges of researchers and engineers with developing countries", rather than with counterparts in developed countries (Figure 1-2-3). Japan is committed to accepting more researchers from developing countries, and to dispatching of more Japanese researchers to these countries.

Measures are necessary to support dispatched researchers through preparatory education and support for both research activities and life in the locality. Also, steps should be taken to ensure continuity of joint activities so that the exchange can contribute to heightening the science and technology level in the host countries. In this respect, involvement by young researchers is essential. At the same time, in developing countries where infrastructure for science and technology is still weak, cooperation by senior researchers who have abundant experience in various fields will be helpful.

Lack of opportunities for mutual communication would hinder exchange activities by researchers. To improve this, it will be useful to hold a number of workshops and seminars, as well as to publish an English list of researchers and laboratories which are willing or capable to conduct joint work or cooperate with developing countries. At Japanese national research institutes, the small research work force as a whole and the difficulty of appropriate personal treatment for researchers after their coming back to Japan, are limiting the absolute number of researchers who can really participate in research exchange activities. To improve the shortage of human resources, it will be helpful to obtain data on those senior researchers who are capable and ready to cooperate.

In conducting joint research activities with developing countries, it is essential to establish research themes which would be beneficial for both parties involved, by conducting close studies on the needs and situation of host countries. Concerning cooperation with developing countries, necessary information is often lacking in both countries; therefore, it is essential to start with close communication and preliminary feasibility studies toward obtaining effective results.

1.2.3.7. Basic Research Activities by Private Companies

1.2.3.7.1. Basic Research Institutes

With greater importance placed on basic research activities, Japanese private companies have begun to establish basic research institutes both inside and outside Japan, hoping that success in basic research will bring forth technological innovation which will further business profits in the future. There are some cases overseas that private research institutes played a leading role in enabling scientific and technological breakthroughs through opening up the doors of their laboratories to outside researchers. According to the "Survey on Private Enterprises' Research and Development", 81% of the respondents agree with the necessity of establishing such institutes dedicated to advanced research and appreciate them positively. However, there is a big gap between the recognition of necessity and the reality, namely only 1% of Japanese private companies have such institutes, and another 1% plan to establish such institutes. It is expected that these open advanced institutes will contribute to future progress of basic research efforts (Figure 1-2-20).

1.2.3.7.2. Publication of Results

While the number of private companies which have basic research institutes is still not large, the above survey indicates that about 50% of private companies have been conducting basic research activities, and 17% answered that the

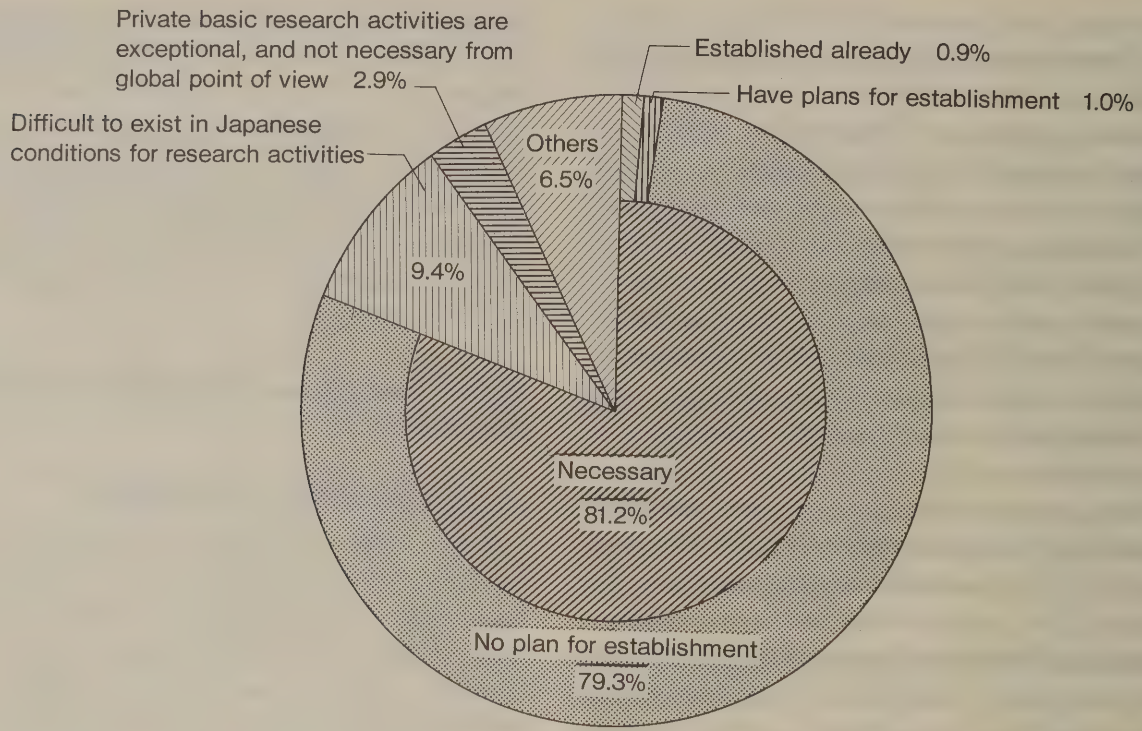


Figure 1-2-20. Establishment of leading basic research institutes by porivate corporations

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

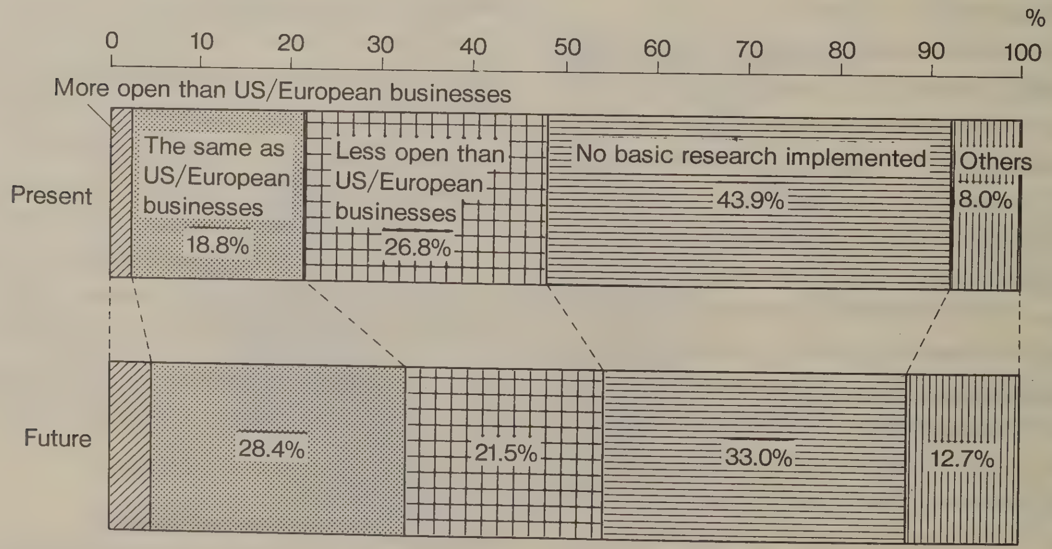


Figure 1-2-21. Publication of results of basic research by private corporations

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

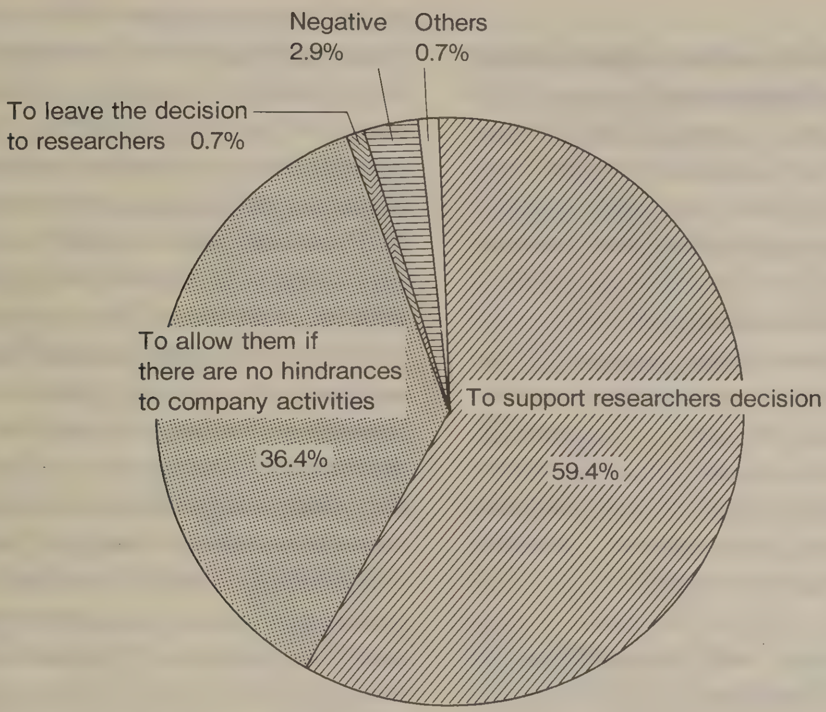


Figure 1-2-22. Attitude of private corporations toward the publication of basic research results by their researchers in academic societies

Source: Science and Technology Agency: "Survey of High-tech Researchers and Engineers (FY1991)"

successful results of basic research are published openly in the same way as do US and European companies. The percentage of these open-minded Japanese companies is increasing; some of them even claim that they are more willing to share successful results than US and European companies (Figure 1-2-21). It may be necessary in the future for the publication of successful results of basic results in private companies to increase the number of companies which "publish the results more openly than do US and European companies" in comparison with the number of those which "publish the results less openly than do US and European companies". About 60% of these companies support publication of successful outcomes at academic societies. Combined with those companies which are willing to publicize as long as no inconvenience is caused to business, a total 90% of the companies are willing to take an open attitude regarding basic research (Figure 1-2-22). Consideration should be given so that successful results of basic research activities by private companies, except for know- how, are publicized through patents or papers without delay. Attention should be paid not to be misunderstood as if Japanese companies would delay the publication of the results without specific reasons or would not publicize them intentionally. It can be said to be a duty of research management in private companies to provide researchers with opportunities to publish their research results as far as possible. Also, results obtained at the Japanese companies overseas R&D facilities should not only be treated by local rules, but also should be made to the locality because returning research results to the locality is necessary to ensure co-existence and co-prosperity between these companies and the local societies.

1.2.3.8. Universally Accepted Management Method by Private Businesses

As Japanese private companies expand their R&D activities beyond national borders, difference in social institutions and customs between Japan and the locality, as well as difference in methods of management of research activities, have become more apparent. There also are some cases where management practices in this country cannot be accepted universally. Japanese companies thus must review their own research management practices and establish universally accepted management methods which are rational and transparent.

1.2.3.8.1. Conformity with Regulations of overseas research institutes

Japanese private companies are expanding research and development activities rapidly, and are accepting more foreign researchers in Japan. It has become important to improve the research environment in Japan for those foreign researchers in accordance with universal standards.

According to replies to the aforementioned survey's question whether the respondent companies are considering in Japan the adoption of same or similar rules as those in their overseas R&D facilities or in the R&D facilities of foreign companies, the number of private companies replying that they "Will adopt the same or similar rules" regarding the "Treatment of the outcome of research activities", and "Joint research with other organizations", is larger than those who "Will not adopt". This indicates that the effects of globalizing R&D activities have been seen already within Japanese private companies. It is useful to respect common rules with the other party when implementing "joint research programs with outside groups". Private companies have been moving toward sharing successful results of their research activities as seen in these replies regarding the "Treatment of the outcome of research activities". However, at the same time, a large number of companies

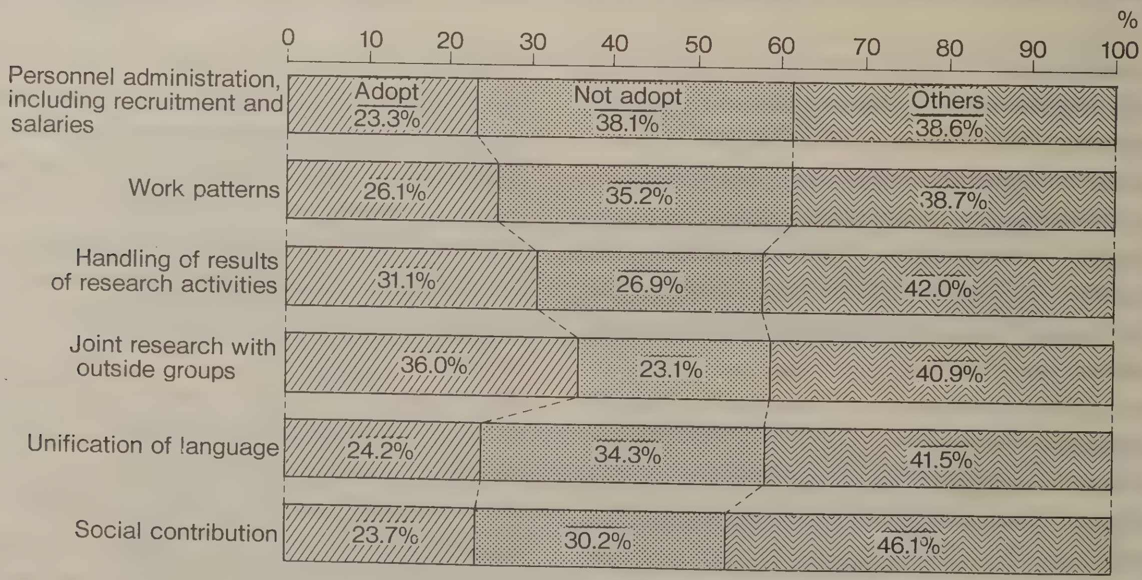


Figure 1-2-23. Adoption of same/similar rules by companies as exist in their overseas R&D facilities or in overseas companies' R&D facilities

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

replied that they "Will not adopt the same or similar rules" regarding "Personnel management such as recruitment and salaries", and "Work patterns". Still, more than 20% of the responding companies are willing to "Adopt the same or similar rules" even regarding personnel administration and work patterns. This indicates that globalization of R&D activities has started to influence companies' core issues such as its personnel management system. Regarding unification of language (e.g. to write both in English and in Japanese), the number of companies which responded that they "Will not adopt" are larger than those who replied that they "Will adopt". However, the percentage gap between these two groups was less than 10%; this indicates that companies which promote language unification will increase in the future (Figure 1-2-23).

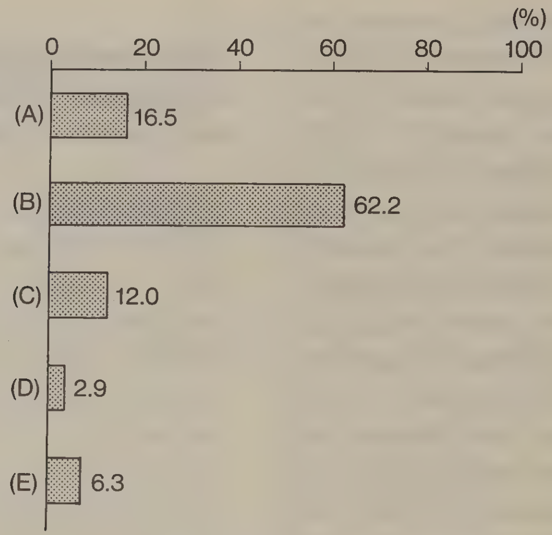
As more foreign researchers join R&D activities both inside and outside Japan, communication in the forms of internal documents, information bulletins, electronic mail and bulletin boards through computer network, etc. will not be effectively conducted only in Japanese. Use of only Japanese in correspondence between managers in the homeland and Japanese researchers in R&D facilities overseas would cause apprehension and uneasiness among foreign staff including researchers working at those overseas facilities. So, wider use of English or parallel use of Japanese and English will be necessary to help personal communication and information exchange with foreign researchers. Use of an universal language also helps Japanese researchers who have geographical disadvantage in international research exchange to receive real time information services through computer networks, which not only gives them a great merit but also helps foreign researchers' access to Japanese researchers and information sources in Japan and contributes to further promotion of information exchange.

1.2.4. Common Set of Values and Rules to Support Globalization of Scientific and Technological Activities

While globalization of scientific and technological activities has contributed to the development of various countries worldwide, people have come to expect science and technology to help solve global problems related to the survival of mankind, such as environment, population and energy.

Not only efforts by researchers and engineers but also fierce competition in R&D activities has driven the continued advancement of science and technology. If the government is tempted to protect successful results obtained within the country, development may make no headway globally. In recent years, scientific discovery and knowledge can sometimes be utilized immediately for technology development, and there have been times that governments are tempted to prevent the outcomes of their domestic scientific research activities from diffusing to other countries. If this tendency becomes more conspicuous, free research activities and fair competition would be hampered. According to the "Survey on Private Enterprises' Research and Development", responding companies foresee continued tension among countries. To the question on future international circumstances around Japan in the field of Science and Technology, 76% of the respondents replied: "Efforts to cooperate continue, thus international tension will continue locally and intermittently, reflecting competition among three powers, i.e., the US, Japan and Europe", or "Each country seeks to strengthen its science and technology ability as a source of economic power, thus tension between them will be growing" (Figure 1-2-24). Efforts should be made continuously for international harmonization and cooperation.

It is necessary for countries to establish common ideas in a global context, taking into account that pressing issues for mankind such



(A) Each country seeks to strengthen its science and technology ability, thus international tension (technology friction) will grow
(B) Efforts to cooperate continue, thus international tension will continue locally and intermittently
(C) International cooperation will increase, thus international tension will be reduced
(D) Japan, the US and Europe become economic blocks, thus international cooperation will decrease and international tension will be reduced
(E) Others

Figure 1-2-24. Future international circumstances around Japan in science and technology

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

Figure 1-2-25. Common set of values and rules to support globalization of S&T activities

as the global environment, will become more serious. Establishment of such a common set of values will match the national interest of Japan which is part of the world community. Japan may need even to take lead this direction.

1.2.4.1. The Need for Common Values and Rules

Common values and rules supporting globalization of scientific and technological activities should include the following (Figure 1-2-25):

First, scientific and technological activities must aim for the harmonious co-existence of mankind and the earth. Deterioration of the natural environment has come to menace survival of all lives on the earth. Results obtained through science and technology are expected to provide effective solutions to these problems. However, we should note also that wrong use of science and technology could impact negatively on mankind. Science and technology also are expected to provide assistance to developing countries' economies take off, and improve the gap between the North and the South. Thus, for the harmonious coexistence of mankind and the earth in a broad sense, it is necessary to secure a foundation for existence and survival of all lives on the earth.

Secondly, to ensure development of science and technology, it is necessary to make researchers and private companies implement R&D activities under a similar framework. Researchers all over the world are competing fiercely in basic science, and private companies are rivaling hard with each other in technological innovation. Measures should be taken to ensure fair competition by establishing common ideas and rules, so that government-supported research projects open their doors to participants from foreign research institutes and or companies, and to make sure that differences between countries in intellectual property rights system and standards does not discourage fair competition.

Thirdly, research activities now cross national borders, and active information exchange and burden-sharing among countries enhance the efficiency of research projects. Some huge scale projects are no longer controllable by a single nation. Multi-national engagement thus has become necessary in megascience projects in terms of funds, human resources and technological assets. Common discretion is necessary also in this kind of international cooperation.

In summary, globalization of science and technology poses to us a need for common values and rules; that is the need for "coexistence of mankind and the earth", "implementation of R&D under a similar framework", and "development of international research cooperation". For the convincing establishment of the above-mentioned ideas, it is necessary to make them rational, universal and systematic. The following paragraphs deal with the substance of common values and rules which support globalization of scientific and technological activities.

1.2.4.2. Harmonized Coexistence of the Mankind and the Earth

1.2.4.2.1. Global Environmental Problems

In the efforts to solve global environmental problems, science and technology are to be regarded as instruments to enable harmonized co-existence of the mankind and the earth, rather than a means to pursue economic prosperity or a form of culture with which mankind aspires to search for truth. Cooperation is in principle necessary for solving global environmental problems; public research organizations of each country should take the initiative in strengthening cooperation and in efficiently promoting international joint research.

1.2.4.2.1.1. Promotion of International Cooperation in Observing the Global Environment

Besides independent activities by each of the developed countries to observe the global

environment, the United Nations Environment Program (UNEP) has been coordinating and cooperating with international bodies and each country's government. Also, the World Meteorological Organization (WMO) is pushing ahead with the World Climate Research Program (WCRP) in co-operation with the ICSU. In that course, the Tropical Ocean and Global Atmosphere (TOGA) and the World Ocean Circulation Experiments (WOCE) already have started. Multilateral joint research programs led by international bodies should be given greater emphasis.

Countries should cooperate closely to ensure efficiency in global environmental observation by sharing responsibility by region or by technology areas.

1.2.4.2.1.2. Use of the Results of Research and Development for Developing Countries

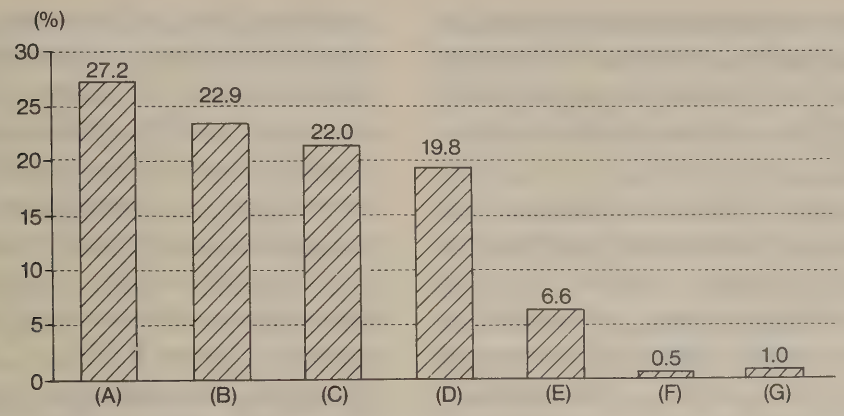
People have been working hard to solve environmental problems through development of alternative energy resources, such as nuclear power and natural energy, technology for efficient use of energy, and alternative materials for CFCs. Research and development on these matters are conducted under the leadership of the advanced nations. However, from now on, establishment of a foundation to ensure smooth application, popularization and transfer of the technology developed for solving the global environmental problems will be an important issue. Developing countries will need this technological know-how at low cost. If it is difficult for them to introduce expensive technology which is kind to the environment, they may be tempted to adopt cheaper technology. In order to prevent such cases, policies are necessary to make it easy for the developing countries to utilize environmental protection technology developed by the advanced nations.

1.2.4.2.1.3. Efforts Urged Worldwide Concerning Science and Technology

Concerning the CFCs, it was agreed that certain kinds of CFCs would be removed by the year 2000, according to a reduction plan stipulated in Montreal Protocol on Substances that Deplete the Ozone Layer in June 1990. As for global warming, the Intergovernmental Panel on Climate Change (IPCC) is studying scientific knowledge, environmental/social economic effects of, and countermeasures. Consultation has been conducted with the aim of working out a draft of an agreement on a climate change framework by the time of the United Nations Council for Environment and Development (UNCED) scheduled to be held next June in Brazil. To establish such international goals, highly reliable data and scientific information are necessary, but environmental problems still involve a number of aspects which are yet to be elucidated. We must strive to illuminate the problems through united efforts by governments.

At this critical juncture in global history, apart from fostering domestic industrial technology, policies should be promoted which reflect researchers' opinions, from an international point of view, and efforts should be made to develop technology for solving environmental problems. Public research institutes in each country should gather to play a leading role in comprehensively seeking scientific understanding based on data and advanced technology. Establishing such an environment is in great demand internationally.

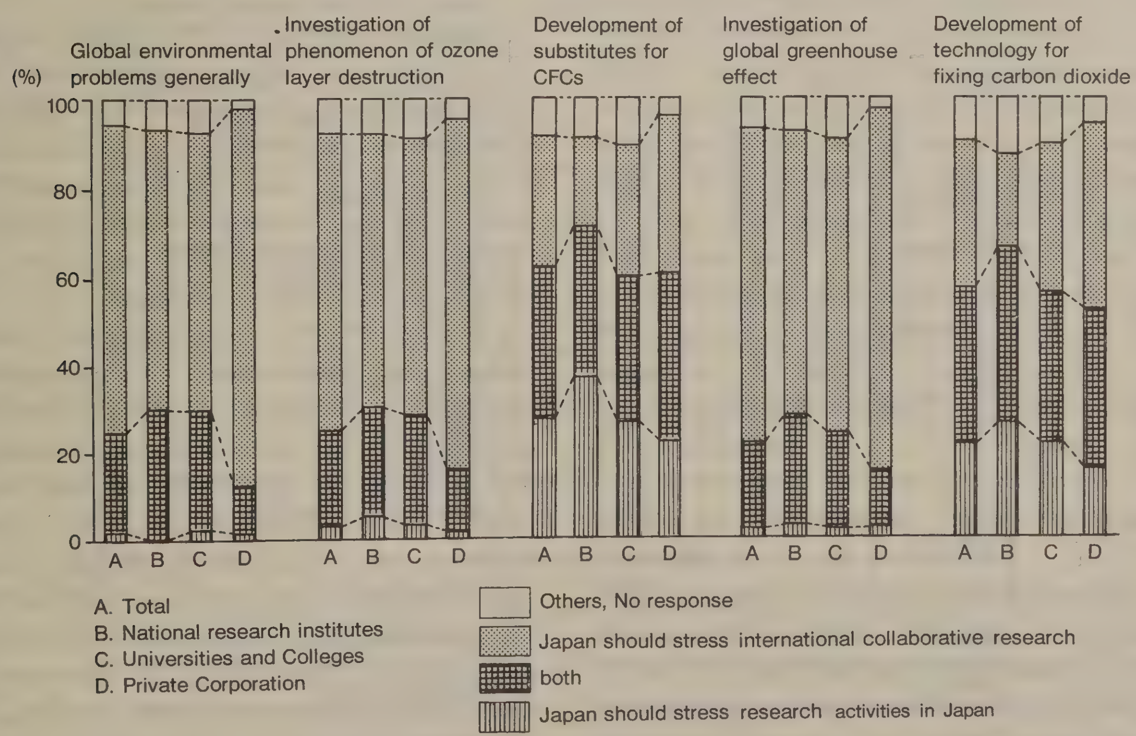
In the manner that Japan's companies overcame past restrictions on automobile emissions due to severe regulations, private companies also are expected to play an important role in the development of technology for solving environmental problems. Practical measures to settle the problems in promoting the private sector's development of technology will be useful. For this purpose, standardization of



(A) Standardization of legal restrictions among countries
(B) Developed nations' leadership in setting goals and promoting effective countermeasures
(C) Mutual understanding of differences in recognizing specific problems
(D) Smooth promotion of international joint research
(E) Understanding by developing countries of environmental issues
(F) Others
(G) Changes not necessary

Figure 1-2-26. Changes in global environment necessary for private corporations to contribute to solving global problems

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"



A. Total
B. National research institutes
C. Universities and Colleges
D. Private Corporation

Figure 1-2-27. Recommended ways to conduct R&D on global environmental problems

Source: Science and Technology Agency: "Survey of High-tech Researchers and Engineers (FY1991)"

regulations and restrictions among countries, the setting of goals, and the promotion of concrete measures under the leadership of advanced nations also will be useful as effective policies (Figure 1-2-26).

All the countries of the world, because they co-exist on earth are responsible for setting up methods for measuring effects of the consumption of fossil energy, ultimate technology, and new materials that will be invented or developed in the future, in an effort to establish economic mechanisms and lifestyles which are kinder to the earth's environment.

1.2.4.2.1.4. Japan's Role

Japan should utilize its high-level R&D capability for technological development -- alternative energy resources for petroleum, the efficient use of energy, development of substitutes for CFSs, fixation of carbon dioxide, etc. Moreover, it is required that Japan take an active part in international cooperation in research on the destruction of the ozone layer, the elucidation of the global warming phenomena and its effects on the society and the economy (Figure 1-2-27).

Besides multinational joint cooperation, accumulation of the results of observations made in many different places will be useful to understand global-scale phenomena. Therefore, each country should continue conducting basic observations. Most of data on the earth's

Table 1-2-28. Observation points of background ambient air pollution (CO_2 monitoring through BAPMON (WMO))

Country	No. of points	Year observation started	Locations
US	4	1958,73,76,81	Hawaii,Alaska(Barrow),Samoa, Antarctic
USSR	4	-	Novosibirskie Is, Northern Part of Kora Peninsula, Bering Island, Atlantic Ocean
Germany	8	1981	Within Germany
Canada	3	1975,76	North Polar Region, Eastern and Western End
Australia	1	1976	Within Australia
Italy	1	1978	Within Italy
France	1	1981	Indian Ocean (Amsterdam Is)
New Zealand	1	1981	Within New Zealand
Peru	1	1983	Within Peru
Japan	1	1987	Ryori(Sanriku-cho, Iwate Pref.)
Hungary	1	-	Within Hungary
Spain	1	-	Canary Is.
Barbados	1	-	Within Barbados

Source: WMO

environment, such as those on the concentration of carbon dioxide, have been accumulated so far through observations by the US, in addition to international bodies, but Japan, too, must also take positive action, beginning with our public research bodies' activities (Figure 1-2-28).

It is expected that Japanese private enterprises will cope with environmental problems more positively by utilizing their world-renown technical capability. In April 1991, the Federation of Economic Organizations (Keidanren) announced its charter on the environment of the earth. In addition, according to the Survey on Private Enterprises' Research and Development, 48% of surveyed private companies are conducting or examining research and development to cope with environmental problems. Japanese enterprises are becoming more interested in environmental problems; government efforts to disseminate appropriate information should take place.

1.2.4.2.2. Securing the Foundation for Living

All the fruitful results of science and technology and things people create come into the hands of those who use them. In the process of globalization of scientific and technological activities, it is also one of our common values that science and technology is to be used to secure the foundations for the continued existence of mankind.

Preventing the proliferation of nuclear weapons is an important task for mankind to keep peace in the world and to secure humanity's base of existence, for example. The safeguards measures by the International Atomic Energy Agency (IAEA) based on the nuclear Non-Proliferation Treaty (NPT) is one of the actions international society has worked out for this purpose. The objective of the IAEA's safeguards is to monitor nuclear materials so that they are not converted into nuclear weapons. Such a monitoring system is expected to deter governments from being tempted to use their nuclear capability, originally used for peaceful purposes, to produce nuclear weapons. IAEA's inspections ensure international control of nuclear materials.

Japan follows the principle of peaceful purposes in conducting research, development, and utilization of nuclear power based on the Atomic Energy Act. The Japanese government signed the NPT in 1976, and the safeguards agreement with the IAEA in 1977, based on its domestic safeguards system. The Japanese government has been calling for other governments to sign the NPT, and to conclude a safeguards agreement with IAEA as well as to accept its inspections.

If rocket technology, etc., is applied to a nuclear delivery system, international tension will increase drastically. Japan therefore is requesting that other countries follow international guidelines for export restrictions on technology that could contribute to a nuclear delivery system, capable of propelling missiles more than certain weight and distance. It is also necessary to lay down stricter restrictions on exports of biological and chemical-related technology that may lead to proliferation of biological and chemical weapons. In September 1991, the conference to review the Convention on the Prohibition of the Development, Production and Stockpiling of Biological and Toxic Weapons and on their Destruction (BW Convention) is going to be held to foster measures to secure confidence in this Convention, and to introduce effective systems for verification.

1.2.4.2.3. Cooperation with Developing Countries

To promote science and technology in developing countries, Official Development Assistance, the manufacturing industry's direct investment, and the increase of Japan's imports are surely effective. Besides, nurturing qualified scientists is critically important so that science and technology will find its niche and be utilized to motivate the development of their societies

and economies. In this sense, advanced nations should not provide them with one-sided and temporary assistance. Advanced nations must respect the developing countries' aspiration for self-sufficiency, and then co-operate with them in their self-supporting efforts for sustainable development. Japan seeks to closely cooperate with these developing countries as one element of our international contribution. Especially cooperation in the fields of science and technology contributes to the development of such countries by assisting them to develop human resources.

The acceptance of researchers and engineers from developing countries and the dispatch of Japanese experts are important to improve their foundation for R&D. Taking their actual circumstance into consideration, Japan should continue its cooperation with these countries. It goes without saying that cooperation with developing countries requires a lot of efforts not only by governments but also by private companies. In order for Japan to be welcomed as a member of the world's society, Japanese enterprises need to appoint more local employees as managers or directors and to harmonize their business expansion with the development of local areas.

1.2.4.3. Common Frameworks for the Promotion of R&D Activities

1.2.4.3.1. Relations between R&D Activities of Private Companies and Governments

In recent years, private companies have come to conduct basic research actively and deserve government support. The government's excessive intervention in private companies' activities may obstruct the development of the market economy at home and abroad. But in the case of basic research, governmental support may not affect the market economy so much, so assistance may be justified. In June 1991, based on the Technology and Economy Program, the Organization for Economic Cooperation and Development (OECD)'s Ministerial Council, in its policy statement on technology and economy, stated that the actual state of governmental support in various countries should be analyzed, and that the possible need for guidelines on government support to R&D would be examined. It is important to aim at harmonizing each country's scientific and technical policies with others.

1.2.4.3.1.1. Governmental Support for Private Companies' R&D

In considering the issue of governmental support for private companies, we need to see how research funds flow from various countries' governments to their private sectors. In Japan, the ratio of R&D expenditures financed by government is very small. Moreover, the share of government funding in total research spending by industry is extremely small in comparison with other advanced countries (Table 1-2-29). With regard to government-sponsored or government-supported R&D programs, there is no indication that Japan stands out in these activities (Table 1-2-30). These data suggest that the outstanding strength in competitiveness of Japanese private companies is not due to government support of their R&D, but to the strenuous effort of these companies themselves.

1.2.4.3.1.2. Participation of Foreign Researchers and Companies in the Government's R&D Activities

It is worthwhile to invite researchers and companies from abroad to take part in the governmental R&D projects, so that they have more opportunities to work in Japan and to exchange ideas with Japanese researchers. In Japan's recent initiatives, such as Exploratory Research for Advanced Technology (ERATO), the Frontier Research Program, the Basic Research Core System, participation is promoted of excellent researchers from throughout the world. Also, foreign companies are beginning to

take part in the Large-scale Industrial Technology Research and Development Program, and the Research and Development Program on Basic Technologies for Future Industries. Wider participation in Japanese governmental R&D activities will facilitate other countries' understanding of Japanese R&D systems. This is expected to contribute to enhancing the transparency of the Japanese R&D system and to improving mutual understanding with other countries' governments.

For foreign participation in government sponsored projects, the difference in the patent systems between Japan and other countries may

Table 1-2-29. Flow of government research funds into industry by selected countries

(Unit: ¥100 million)

Japan (FY1989)		U.S. (FY1990)		Germany (FY1989)		France (FY1983)		U.K. (FY1988)	
Amounts	Share	Amounts	Share	Amounts	Share	Amounts	Share	Amounts	Share
1,028	1.2	71,300	33.0	4,526	11.5	3,646	22.4	3,888	16.5

Note: Share shows percentage of the whole industry's R&D expenditures
Compilation: Science and Technology Agency
Source: Same as Figure 2-1-1 for Japan, US and Germany. OECD Statistics for France, Cabinet Office: "Annual Review of Government Funded R&D" for UK.

Table 1-2-30. Some examples of government-sponsored or government-supported programs relating to private corporations in Japan, the US and Europe

Japan	Cooperative Development of Industrial Technology etc. (JRDC) Large-scale Industrial Technology Research and Development Research and Development Program on Basic Technologies for Future Industries Japan Key Technology Center Bio-oriented Technology Research Advancement Institution Adverse Drug Sufferings Relief and Research Promotion Fund etc.
U S	High Performance Computing and Communications Advanced Manufacturing and materials Semiconductor Manufacturing Technology (SEMATECH) Advanced Technology Program (ATP) Engineering Research Centers GaAs IC Program etc.
Europe	Framework Program (ESPRIT, RACE, BRITE etc.) EUREKA Program etc.

Source: Science and Technology Agency

cause problems. In Japan, when the entity, having accomplished the research, intends to implement the patents obtained by the research, royalties should be paid except for specific cases, but some developed countries allow this kind of use free of charge. In Japan, the aforementioned special cases are seen only in industrial technology areas on the condition that the principle of reciprocity is respected. Because international joint research will increase in the future involving patents held by the government, Japan will be required to review and improve its present system to one more consistent with other countries' systems.

1.2.4.3.2. Intellectual Property Rights

With the rapid advance of the globalization of economic activities in recent years, there is a growing circulation of technology which should be protected by intellectual property rights (IPR), and IPR are increasingly becoming more important. International harmonization is strongly required for the protection level of IPR, procedures for obtaining rights, implementation of these rights, etc.

1.2.4.3.2.1. Disputes over Intellectual Property Rights

Technology is circulating across borders more than before, as Japanese private companies' science and technology activities increase. Disputes with other countries are expected to increase over IPR. According to the Survey on Private Enterprises' Research and Development, those who replied that: "Disputes over intellectual property rights are increasing" exceed those who replied that: "Disputes are decreasing". According to the results by country (or by region), 24% of the companies replied that disputes with the US are increasing. 11% replied that disputes are increasing with Europe, and 9% with Asian NIEs. Problems are increasing in countries (areas/regions) where overseas research and development facilities of Japanese companies are being established (Figure 1-2-31). In addition, Japanese companies which have research and development facilities in the US, Europe, and also in Asia replied that the problem concerning IPR will increase in the future as one issue of management of research (Figure 1-1-49).

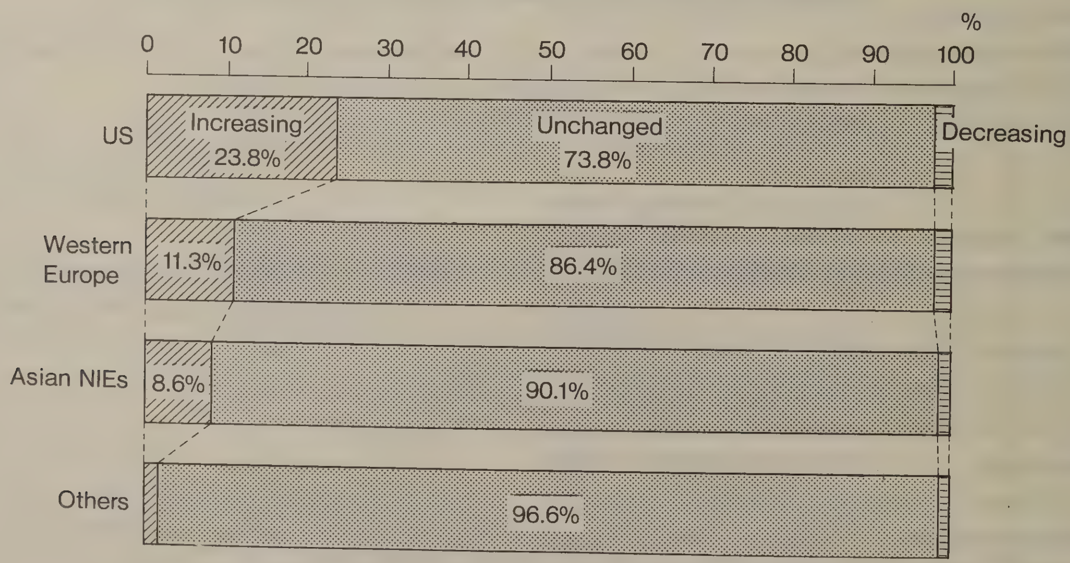
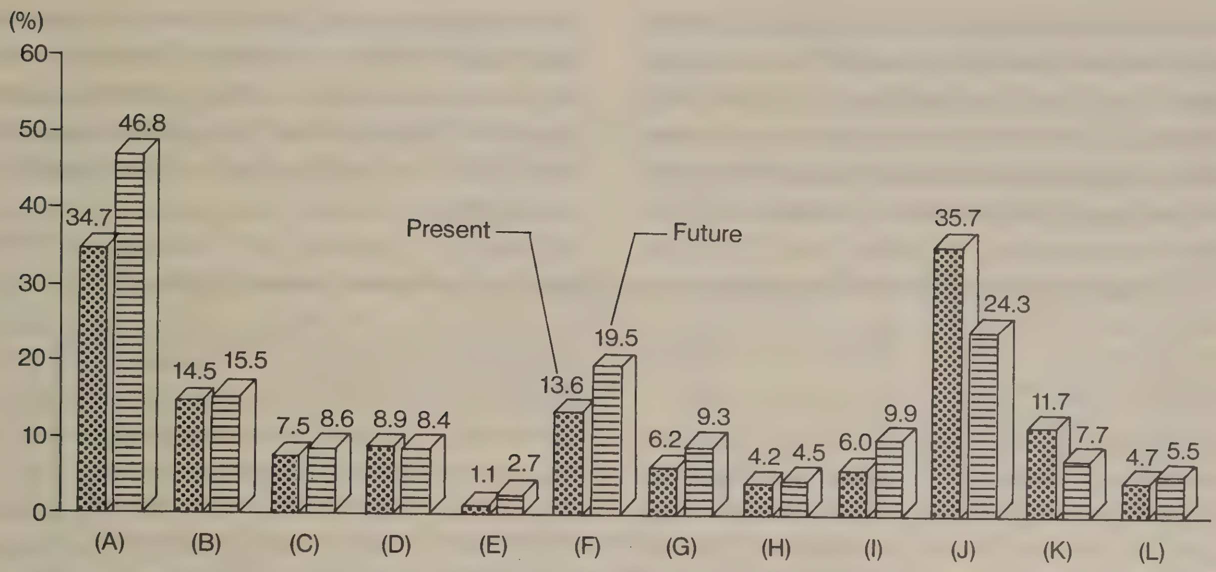


Figure 1-2-31. Conflicts on intellectual property rights in private corporations

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991) "



(A) Problems related to intellectual property rights
(B) Problems related to Export Control Laws
(C) Problems related to Antitrust Laws
(D) Criticism against "free-rider" on S&T
(E) Criticism against enclosure of excellent researchers
(F) Difficulties in technology introduction
(G) Difficulties in access to S&T information
(H) Existence of big technology gap
(I) Ideas on contribution to society
(J) No problems
(K) No relationship with the US
(L) Others

Figure 1-2-32. Present and future S&T-related problems with the US faced by private corporations

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

Furthermore, in replies to the statement "What is expected to become a problem related to science and technology with the US in the future?" companies mentioning IPR reached nearly 50%. This indicates that Japanese private companies are taking the problem of IPR seriously(Figure 1-2-32).

1.2.4.3.2.2. Major Recent Movements on Intellectual Property Rights

By the time of the so-called Young Report (Global Competition: The New Reality; President's Commission on Industrial Competitiveness) in 1985, the US became aware of the necessity of continuous innovation by strengthening the protection of IPR to restore industrial competitiveness. Since then, the US has advocated strengthening the protection of IPR through multilateral and bilateral negotiations. The US is the only developed nation which has adopted the principle of "first to invent". Moreover, concerning applications for patents from outside the US, the US uses the day of patent application as the day of invention; it therefore seems to discriminate between applications from inside and outside the US.

Within developing countries, a group headed by India and Brazil holds that IPR would put a brake on the development of developing countries. Especially concerning patents, they claim that a weak protection of patents reflecting the status of industrial development of each country would be sufficient. From the viewpoint of advanced nations, problems with this view are, for instance, there is no protection of new chemical materials and pharmaceuticals, and when there is, there is only a short period of protection.

Table 1-2-33. Activities of international organizations on intellectual property rights etc.

International Organizations	Objective, Details, Progress, etc.
WIPO	Initiated upon the effectuation of the World Intellectual Property Organization Establishment Treaty in 1970. The deliberation of the supplement treaty for the Paris Convention on Patent (patent harmonization treaty), was begun in July 1985, aiming at establishment of the international standards of patent system. The 1st Diplomatic Conference was held in June 1991. Similarly, studies on plan of a trademark harmonization treaty have been conducted since November 1989. Also, studies on a mechanism (treaty) to solve disputes between countries relevant to intellectual property rights have been conducted since February 1990.
GATT	The US filed an trade issue relevant to intellectual property rights, including counterfeit goods and pirated edition to GATT, aiming at heightening the protection level of intellectual property rights. At the beginning of Uruguay Round of 1986, GATT Ministerial Conference took up TRIP (trade-related aspects of intellectual property rights including trade in counterfeit goods) as one of the major agenda. Countries have been working on this TRIP negotiation for reaching an agreement.
UPOV	In September 1982, Japan joined UPOV. The revision draft which aims at protection of the right of new plant breeder, to meet the rapid progress of biotechnology in plants, was adopted at the diplomatic conference in Geneva in March 1991. Revised items relate to: strengthened right for new plant; introduction of subordinate relationship; expansion of the p]_ants to be protected to cover all types of plants; extension of protection period; change in protection method (deletion of provision barring double protection).
UNCTAD	While developed countries take initiative of GATT, and examine the revision of international patent systems and the formation of international rules concerning technology transfer, developing countries hold UNCTAD meetings once about four years. UNCTAD studies economic issues such as technology transfer.

Systems for intellectual property rights differ from country to country, and international bodies are making efforts to harmonize them and solve relevant issues (Table 1-2-33). The World Intellectual Property Organization (WIPO) aims at making international rules for patent systems. WIPO has been holding meetings of experts for discussing such items as a unified principle of application first, the unification of the term of validity of patents, an obligation to announce applications for patents, time-limits for search and examination, and approvals for applications in the native language. The first diplomatic conference was held this year to mark a significant step forward. Moreover, the GATT/Uruguay Round, too, has taken up intellectual property rights as one of the items for negotiations, in relation to trade. Some of the above-mentioned items are being studied at WIPO and the compulsory right to use a patent has been examined. Besides, standards for the protection of trademarks, logotypes, and copyrights including computer programs and semiconductor chip layout designs, and rules for exercising intellectual property rights (enforcement) have been studied in order to make international rules.

1.2.4.3.2.3. Japan's Response

Japan has realized fully that intellectual property rights are becoming important internationally. Japan has contributed to international society by making concrete proposals and attempting to coordinate among countries at the above-mentioned fora. Incidentally, in Japan, there are too many applications by private companies; thus, the examination takes twice as long as in the US. For this reason, the US is strongly urging shortening of the period of examination for a patent with the aim of strengthening the protection of intellectual property rights against Japan. A large number of applications for patents reflect Japanese companies' enthusiasm for technological development, but on the other hand, patented inventions account for only 30% of the total applications. This percentage is much lower than those of the US and Europe. The Patent Agency therefore encourages not only proper applications and claims, but also shortening the period of examination by taking measures such as increasing the number of examiners, promoting the paperless system and improving examination capacities by using personnel in the private sector.

With regard to relations with developing countries, the Patent Agency is sending experts and accepting trainees for cooperation in setting an intellectual property rights system and making its operation smooth. At present, besides cooperation through the Japan International Cooperation Agency, Japan is providing funds to WIPO. Japan's cooperation is expanding in quantity and in quality.

1.2.4.3.3. Standardization of Industrial Products

According to the results of the "Survey of Private Enterprises' Research and Development", Japanese private companies consider that standardization of products is a desirable common framework for all the countries of the world to conduct research and development, following a unified intellectual property rights system. This indicates that international standardization is important for the globalization of private companies' research and development activities (Figure 1-2-34).

International standardization will contribute to the removal of technical barriers on the trade side, which will lead to increased international trade. Also, it will have some good effects; world-wide circulation of information and a joint ownership of data, the forming of a base for international cooperation in scientific and technical fields, and the fostering of a foundation for the development of industries in developing countries.

Japan has been pushing internationalization of standardization activities so far, along GATT guidelines, but under the present international

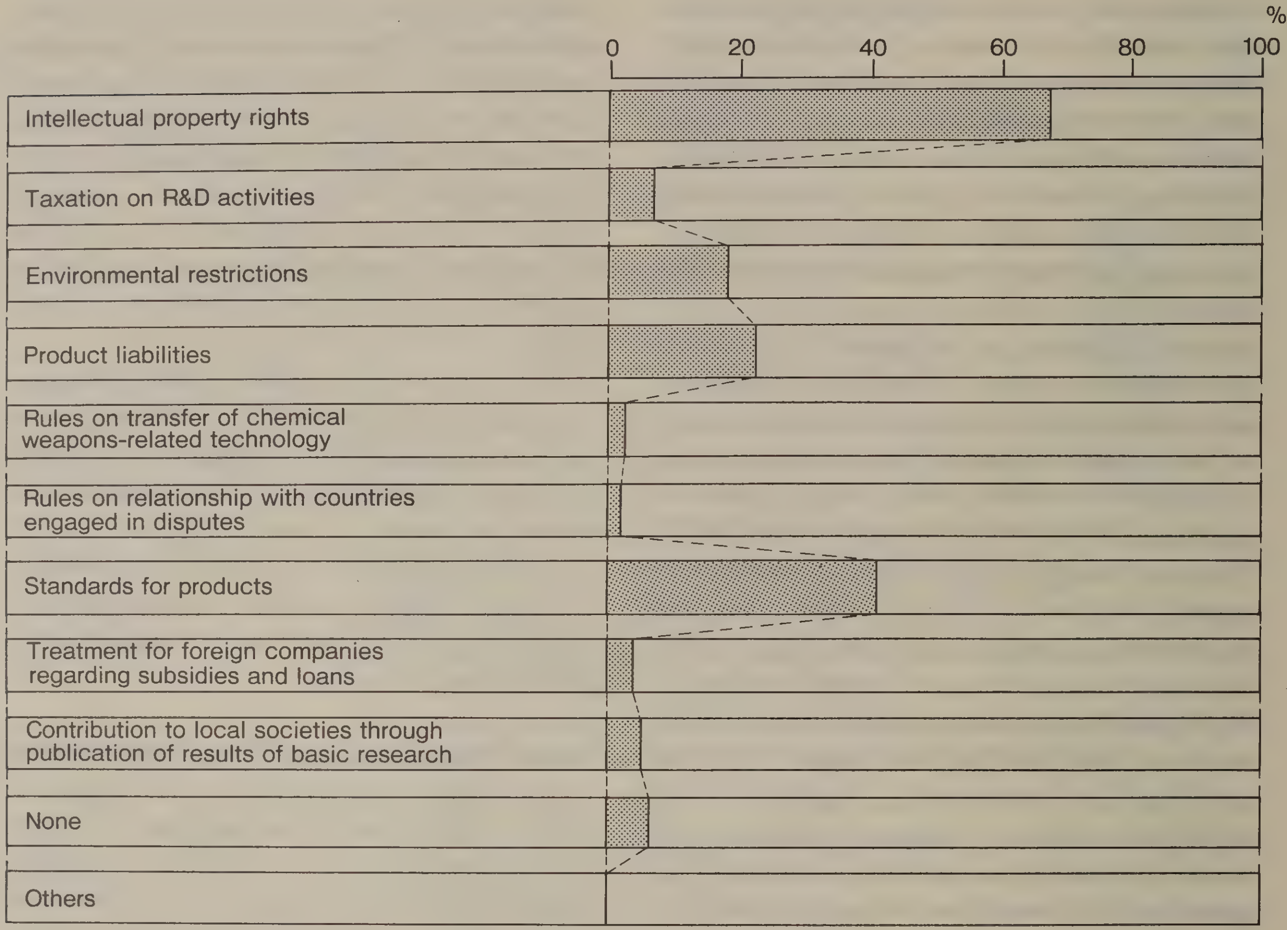


Figure 1-2-34. World-wide common framework for R&D activities hoped for by private corporations

Note: Multiple responses

Source: Science and Technology Agency: "Survey on Private Enterprises' Research and Development (FY1991)"

situation, Japan not only enjoys the merit of international standardization, but also has to conform still further its Japan Industrial Standards (JIS) to international standards and to actively participate in international standardization activities at the International Organization for Standardization (ISO), the International Electronic Commission (IEC), and the International Telecommunication Union (ITU), a UN specialized agency. Great expectations are placed on our country's contribution to standardization especially in the technical fields in which Japan has technical prominence world-wide.

1.2.4.3.3.1. International Standardization of New Materials

To promote international standardization, Japan has taken part in the Versailles Project on Materials and Standards (VAMAS), an international cooperation project on tests and evaluation technology in the new materials field from the stage of research and development. For example, Japan has been conducting joint research activities at all technical working groups for superconductive, very low temperature structural materials, ceramics, etc.

VAMAS was one of international cooperation projects agreed to at the Versailles Summit held in 1982. Its objective is to construct an international coordinated technological base necessary for setting standards and specifications for the use of new materials in order to develop and promote trade in new technology and to remove technical barriers against such development and promotion. Attention is focused on new materials as a key to technological innovation in many highly advanced fields, such as those of electronics, energy, aviation, and space. New materials are ceramics, high polymer materials, metal materials,and compound materials, etc. In these fields, Japan should not only play a role as one participating country but also should bear a leading role due to our highly advanced technology and capability of research. VAMAS has been continuing cooperative activities among the Summit-member nations, and is expected to continue also after 1992. Therefore, Japan should continue its cooperation including the participation of industrial, academic, and government circles.

In addition, a new expert committee, the Technical Committee on Superconductivity (TC90), was established in 1989 at the International Electrotechnical Standard Commission (IEC). International standardization is planned to be carried out under the leadership of Japan, the managing country. It then is expected that research and development/practical use will be promoted based on the standardization of terminologies, test methods, etc.

1.2.4.3.3.2. International Unified Standard for High Definition Television

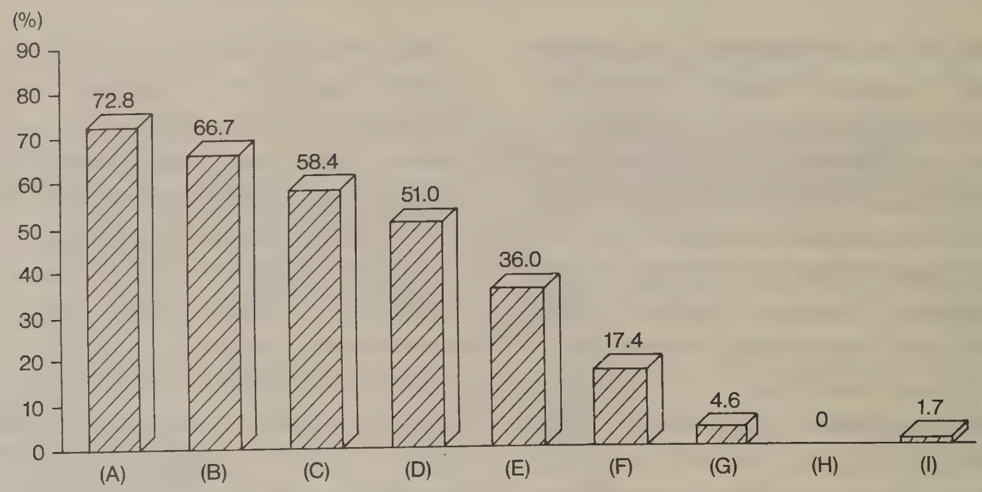
High definition TV (HDTV) is an example of which other countries did not reach agreement, though Japan as a leading country made considerable efforts for coordination. Japan, ahead of other countries, started development of HDTV in the 1960's in cooperation between the Japan Broadcasting Corporation (NHK) and electric appliance companies. After 1970, development of its hardware was started in earnest and new compressed transmitting technology was developed in 1984. At the time of the international science and technology exposition (1985 Tsukuba Exposition), a total system for HDTV had been completed; transmission by terrestrial waves was tested. A regular test broadcast started in June, 1989, through satellite broadcasting. Development of various kinds of equipment for HDTV has reached the stage of practical use. If the Japanese high definition system is adopted, this will become one case where the results of Japan's technical development will be utilized throughout the world.

Concerning international studio standard for HDTV, discussions have been held since 1972 at the International Radio Consultative Committee (CCIR), and there has been a confrontation between the Japanese high definition system and the European system. In May, 1990, the CCIR issued a recommendation, and an agreement was reached on many items for the unification of standards, such as the aspect ratio. The US at first agreed to the Japanese proposal, but in 1989 changed its policy and withdrew support for the Japanese proposal. For this reason, Japan, the US, and Europe are continuing to endeavor to completely unify the standards. HDTV is an example of technological areas where Japan has world-level high technological abilities and where Japan is expected to play an important role in unification of the standards. But the unification is facing rough going due to each country's strategies on technology. This is an example showing the difficulty of unifying standards/criteria internationally.

1.2.4.4. Promotion of International Joint Research

1.2.4.4.1. International Joint Research

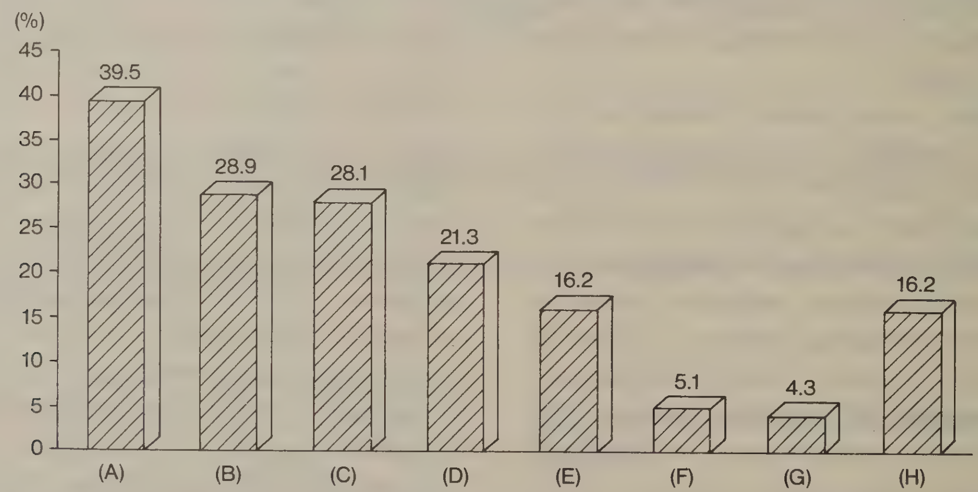
It is expected that expansion and mixing of



(A) Exchange of information and literature
(B) Dispatch and acceptance of researchers, engineers and trainees
(C) Discussion on results of research
(D) Joint research
(E) Provision and acceptance of test samples
(F) Advice for research
(G) No exchange implemented
(H) No exchange necessary in this specific field
(I) Others

Figure 1-2-35. Contents of international exchanges research

Source: Science and Technology Agency: "Survey of High-tech Researchers and Engineers (FY1991)"



(A) To compare results of research in different approaches
(B) No partners in Japan
(C) To complement each others' knowledge and technology
(D) To share costs and manpower
(E) To dissolve geographical restrictions (ex. share of observation points)
(F) Other purposes (No particular merits to note)
(G) To advance the standardization of products
(H) Others

Figure 1-2-36. Reasons for collaborative research with overseas researchers

Source: Science and Technology Agency: "Survey of High-tech Researchers and Engineers (FY1991)"

research fields will continue; interdisciplinary joint research is likely to increase. Also, joint research will be conducted not only inside a country but across national borders as well.

According to the "Survey of High-Tech Researchers and Engineers", 72% replied that "exchange of information and literature" was the main content of international exchanges. 66% replied "dispatch and acceptance of researchers and other personnel", and 57% replied "discussions on results of research". Those who replied "joint research" totaled 50% (Figure 1-2-35). Moreover, in reply to a question asking the reasons for doing international joint research, 38% replied "to compare results of research in different approaches". "To compensate knowledge and technology each other" and "to seeking research partners because there is no partner in Japan" were both selected by 27% (Figure 1-2-36).

Furthermore, in reply to a question about the conditions for cooperating in doing international research, 57% replied "Existence of Mutual Reliance", 18% replied "Existence of agreements on intellectual property rights", 10% replied "contributions of co-authored papers". Researchers at national research institutes and universities replied mostly "Mutual Reliance".

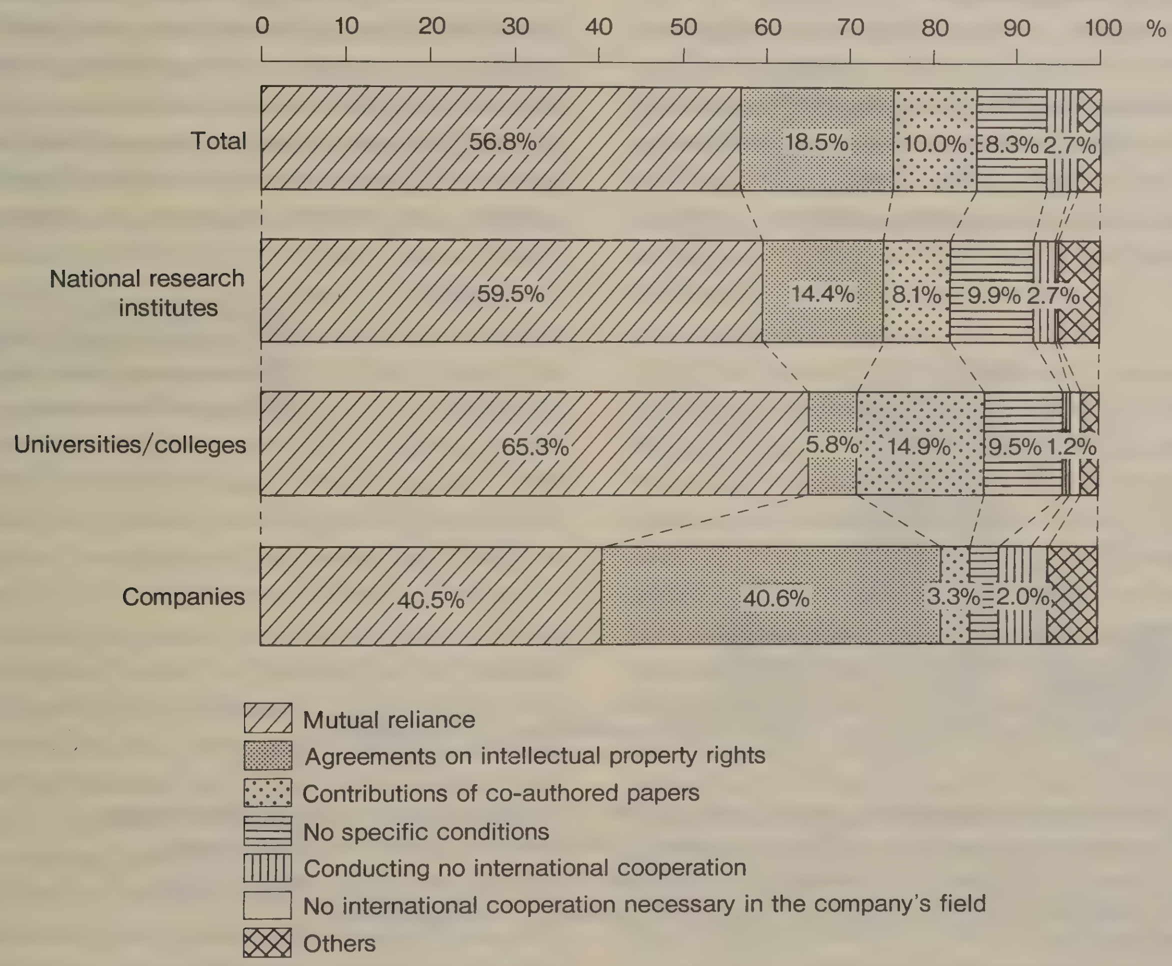


Figure 1-2-37. Conditions for international cooperation

Source: Science and Technology Agency: "Survey of High-tech Researchers and Engineers, (FY1991)"

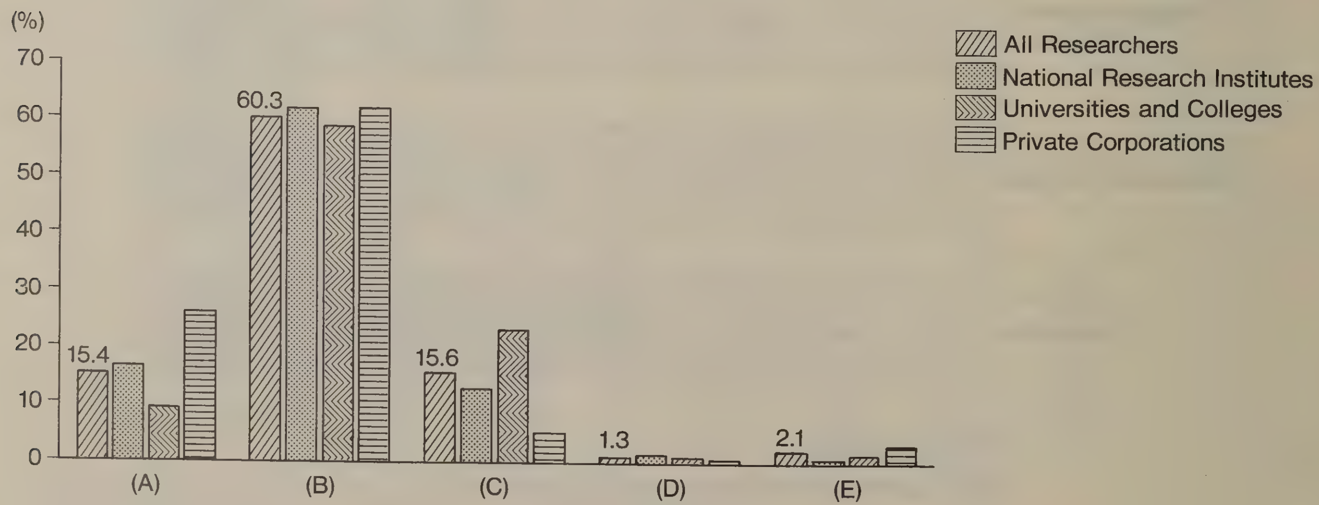
As for researchers in private companies, the most numerous replies were "Existence of agreements on intellectual property rights". In each individual case, it is important to facilitate smooth exchanges of international research in order not to cause any trouble between researchers (Figure 1-2-37).

In addition, concerning joint research with developing countries, surveys and research on tropical forests, oceans, deserts, gene resources, etc., in which nature and the geographical characteristics are made full use of are conducted. Local desire should be respected furthermore conducting joint research.

1.2.4.4.2. Megascience

According to the "Survey of High-tech Researchers and Engineers", a majority (60%) of researchers' believed cooperation in megascience "is desirable, but there should be little diversion of funds from other areas". Those who replied "should cooperate positively, even if some funds will be diverted from other research areas", and those who replied "no need to cooperate, if that would mean diversion of funds from other research in areas", accounted for almost 15% each (Figure 1-2-38). If we take part in megascience projects, ordinary research, also called small science, should be adversely impacted to the smallest extent.

Regarding megascience, it is important for the countries concerned to have common perceptions about it. When promoting it, it is important to fully exchange views internationally from the concept-formulation stage. If one country calls for other countries' participation after finalizing a concept, it will likely cause difficulties in securing others' participation. Moreover, although it is not easy, a method for judging the necessity of establishing large facilities with international cooperation should be created. To implement a plan, must keep their promises. If a country promises to share research activities and research expenses, it must not



(A) Should cooperate positively, even if some funds will be diverted from other research areas
(B) Cooperation is desirable, but there should be little diversion of funds from other areas
(C) No need to cooperate, if that would mean diversion of funds from other research areas
(D) No need to conduct international cooperative research in Megascience.
(E) No opinion

Figure 1-2-38. Researchers' attitude toward megascience cooperation

Source: Science and Technology Agency: "Survey of High-tech Researchers and Engineers (FY1991)"

cause any trouble by breaking its promise.

Countries that consider participation in a project should study in advance the following items: what the research means and the expected results should the research be successful; what conducting international cooperative research means for the country; understanding the research and development capability of other participating countries and each country's role; relations with other negotiations and existing cooperative projects. After a plan starts, the right to make changes should be ensured through a management framework. In any case, at least judgments concerning the direction of the policy should be made promptly if a proposal is made by another country for participation.

When promoting a certain plan, the following matters will be important: to make the objectives of a plan clear before it starts; to clarify the method for making changes; to manage a plan efficiently and facilitate smooth international cooperation; to estimate and secure the expenses necessary to keep facilities/plans; and to ensure appropriate protection and allotment of intellectual property rights. In addition, it ought to be considered whether a plan should be composed of two parts -- one in which all countries will participate and the other in which some countries upon their choice will participate. Furthermore, depending on circumstances, it also should be considered whether a time for a review of participation will be set. Countries in which research facilities will be constructed need to provide an appropriate environment by preparing a system to accept researchers from every participating country so that the plan will be successful. This is different from countries merely providing funds or dispatching researchers.

When considering megascience projects, it will be necessary to study at existing frameworks of bilateral cooperation and international bodies, thus leading to mutual understanding among the countries concerned.

1.3. Our Expectations for Science and Technology at this Critical Juncture in the World's History-Tasks and Prospects for Japan

1.3.1. Changes in the World and Science and Technology

Because of steady efforts, science and technology has become one of the indispensable elements in our society. Without specifically being recognized, it is not only felt in our daily lives, but also in globally. The drastic social changes, exemplified by perestroika in the Soviet Union which led to the democratization of East Europe and the dissolving of the Warsaw Pact and the unification of Germany, are said to have been caused primarily by the big economic gap between the East and West. But primarily they were caused by the fact that in the western world, the progress of information and communication technology has been so rapid that it had become impossible in the Eastern bloc to keep controlling information.

On the other hand, after many years of expanding our activities in a great variety of fields, we came to learn of such environmental problems as global warming, caused by an increase of carbon dioxide, and the gradual destruction of the ozone layer because of the use of CFCs. Global countermeasures are necessary to try to find solutions. Although it has been discussed, for instance at the Club of Rome in the 1970's, that the earth is finite, people have had to come a long way before they actually understand the importance of these problems. The economic gap between the North and the South was pointed out long ago as a serious problem, yet the gap is widening further, rather than being narrowed. To settle these problems, science and technology is becoming ever more important; great expectations are placed on the ways and means which science and technology activities would possibly be able to provide us.

1.3.2. Japan in the Face of Globalization in Science and Technology Activities

Along with the progress of the Japanese economy, the international community is expecting much more of Japan than Japanese imagine. In Japan, calls for "internationalization" have been heard for a considerably long time, but we tend to think domestically because of the limited volume of information from abroad. We thus are required to take a broad view of things; we need to persevere in our efforts not to widen, but to narrow the difference between other countries' views of Japan and ours. Science and technology is an original field in which it is proper for us to contribute to international society.

As analyzed in Chapters 1 and 2, science and technology activities have expanded across borders and the interdependence between countries has greatly deepened. This deserves to be called "Globalization". In our country, progress in science and technology, especially as made by private enterprises, has been marked both inside and outside Japan, as witnessed by the increase in high-tech exports to the world market, improved quality of registered Japanese patents, and sharp increases in the number of R&D facilities established abroad. However, when compared to the level of technology we have reached, our basic research still has a long way to go, as understood from the relative level of basic research and from statistics on the number of citations and co-authorships of research papers, and the number of Nobel Prize laureates in Japan. The imbalance between the level of basic research and that of technology, represented by high-tech products, is extremely large in Japan compared with other advanced countries. This situation is reflected in the US and European countries' criticism of Japan as a "free rider" on the success of basic research obtained in other countries. In the eyes of other countries, Japan sometimes appears to be a "black hole" which only absorbs but does not give off, information -- it is said that this notion underlies the potential anti-Japanese sentiments in the US and Europe. We may have failed to recognize the importance of basic research, being too much captivated by the success of high technology, especially in the fields of information and communication technology.

1.3.3. Tasks Facing Japan

One of the most important issues at the moment is what action Japan is going to take in the future. Science the Meiji era, Japan has benefitted from the fruits of science and technology, including basic research, brought in from European countries and the US. Even if other governments are tempted to take protectionist policies, partly because of apprehension about Japan's success, we have to take the initiative to advocate globalization of science and technology activities based on a positive-sum view, so that other countries as well would be able to enjoy the fruits of Japanese activities. The first task is "to become a genuine member of the world research community by harmonizing domestic activities with those in other countries". The second task is "to play an active role in establishing respectable values and rules common to each country in order to support the globalization of science and technology activities".

1.3.4. Achieving Internal Globalization Our goal should be to make domestic R&D activities as a genuine member of the world's research community.

To improve and develop basic research in Japan, the first task is to improve various factors to enhance research activities, including research expenses, personnel, facilities, support activities and international exchange systems. In other words, its goal is to accomplish "internal globalization".

It is necessary for our country to ensure that the results of Japanese research and development will diffuse to other countries to the same degree, or even higher, as has been the case with US and European research results. This requires that Japanese research institutes should function as a center for the creation of public assets or intellectual stocks which would attract foreign researchers to work in Japan. Basic research should pursue truth or develop solutions for global environmental problems for the co-existence of people with the earth, rather than giving priority to finding technological sprouts which grow into industrial development. In these essential areas, Japan is not yet a center of research or a source of high-level information, although globalization of science and technology activities has been making progress in Japan to some extent. This is understood also from replies to a questionnaire by Japanese researchers that they feel isolated from international researchers' networks.

To improve this situation, the first task is to enrich research and development activities in the public sector.

Second is to secure human resources. Large numbers of excellent researchers are indispensable to supporting high-level science and technology activities. A concern is that science and technology is becoming unpopular among young people, as seen in a decrease these days in the number of high school graduates who enroll in university departments of science and engineering. This has cast gloom on the future progress of science and technology in Japan, and is compounded by an expected sharp decrease in the population of young people at the beginning of the 21st century. Countermeasures should be taken as soon as possible, because this type of problem takes a long time to solve. Science and technology, in every aspect, bears a very important role in supporting the prosperity of mankind. To encourage young people to enter the fields of science and technology, it is necessary to hand down the excitement and pleasure that only the researcher can feel at the moment of the discovery of a truth or invention.

Third is that we have to exert ourselves to improve the "research environment". The research environment in Japan no doubt is inferior to those of Europe and the US. Nevertheless, the level of science in Japan has been rising, resulting from fierce competition among researchers as well as from their devoted efforts. However, it is not desirable for a society to depend excessively on individuals' efforts and their patience. We must change current values so as to place more stress on people's creative activities. We must make it possible for researchers in Japan to carry out their research in an environment equivalent to that at the international level.

Fourth is to promote the acceptance of researchers from abroad and to improve the infrastructure needed to do this. The government has been promoting the acceptance of researchers by national research institutes and universities since the new Japan-US Science and Technology Cooperation Agreement was signed in 1988, and some successes have resulted. There are indications that research institutes in the future will have a larger number of foreign citizens. It is still necessary to prepare a more flexible and comprehensive system to support researchers from other countries in all aspects of their activities and life in Japan, including offering job opportunities for their spouses and education for their children. To lighten the burden of individual Japanese researchers in helping out these foreign researchers, we need to set up a comprehensive system, including organizing volunteer activities, similar to those of universities and colleges in Europe and the US. Improvement of the English proficiency of the Japanese people is not only a task of researchers but also that of those who will help foreign researchers to live in Japan.

1.3.5. Commitment to Common Values and Rules

The second task aims at playing an active role in establishing values and rules common to each country throughout the world.

In creating common values and rules, the first important point is that science and technology activities must serve the harmonious coexistence of mankind and the earth. Regarding environmental problems, among others, advanced nations are required to take the initiative and secure long-term cooperation in conducting scientific analysis. It is difficult to find something decisive to improve the gap between the Northern and Southern hemispheres in the face of the increasing population in developing countries. It is necessary to stress wide-ranging cooperation with developing countries in science and technology areas, so that they can strengthen their technological capability base, which will help them acquire a higher level of self sufficiency.

The second important point is to provide researchers in private companies in different countries with similar conditions (a common framework) to conduct research and development, for instance regarding participation in government-sponsored or government-supported research projects, intellectual property rights systems, etc. In recent years, Japanese private companies have been establishing more and more research facilities overseas, and have been hiring a large number of researchers locally. This movement has been much more rapid than were the cases of foreign businesses establishing research facilities in Japan. We need to be cautious so that this kind of movement itself will not lead to apprehension and frictions abroad which now are expected.

The third point is that countries need to build a common view on how to cooperate with each other in conducting international joint research programs including those related to mega-science.

The last point is that in case Japan intends to help establish common values and rules, or in case one country enforces a strategic science and technology policy, this country should have a good mutual understanding with other countries concerning the prevailing world's framework, since countries are becoming more and more interdependent in terms of science and technology. It is not easy for the Japanese people to have an objective view of their own country. Yet through the surveys by STA and the US Department of Commerce, it was made clear that responding researchers have fairly similar views on the Japanese and US technological levels. Information on the perceptions of specialists should be shared not only by individual researchers but also by a wide range of people including policy-makers. Researchers in a field may know the level of achievement in his specific field, but few would have an overall picture of Japan's science and technology capability. For instance, through the Japan-US or Japan-US-EC joint surveys on their respective levels of science and technology, each government is able to come to a precise common and objective understanding of the present situation, as it begins to formulate a new policy. This can lead to occasions for exchange of opinions among people responsible for policy-making, based on the same factual data. These efforts can contribute to enhancing the international aspects and transparency of each country's science and technology policy, and finally to avoiding unnecessary frictions in the future.

1.3.6. Conclusion

From the international point of view, Japan should take the initiative in promoting the globalization of science and technology activities of the world, and actively take part in further developing the world's science and technology while recognizing its proper position in the

international society. Furthermore, utilizing science and technology, Japan should contribute positively to solving global issues which exist at this critical juncture for mankind. Steady inconspicuous efforts in these activities may be the shortest way for Japan to win the respect of the world in the future. This is the real challenge ahead of Japan as it looks toward the 21st century.

Part 2. The Status of Science and Technology in Japan and Other Nations

Governments of major countries are actively promoting their own science and technology policy to challenge the limits of human capabilities; to provide solutions to worldwide concerns such as the global environment, natural resources and energy; and to add to the strengthening of competitive industrial power. Industries in the world are increasing investments in research and development(R&D) to cope with competition in product development and the trend toward high-tech products.

Japan, including its industries and other sectors, has been actively investing in R&D, and its international position in science and technology is considered to be rising steadily. Its R&D activities need to be strengthened and expanded further to seek qualitative improvements in the life of its people and to accomplish well-balanced economic growth.

Part 2 describes Japan's relative international position in science and technology, as well as Japanese research activities[1]. This is done by comparing data on R&D expenditures, number of researchers, and other activities for selected countries.

2.1. R&D Expenditures

2.1.1. Total R&D Expenditures

2.1.1.1. Trends in R&D Expenditures

When a country examines its R&D expenditures[2], its contents and approach may differ from other nations. As a result, a simple comparison of R&D expenditures among countries may not present compatible data, although it gives a general idea as to a country's attitude toward science and technology. In terms of R&D expenditures, the United States spends the most followed by Japan and Germany[3] (Figure 2-1-1).

2.1.1.2. Increase of R&D Expenditures in Real Terms

R&D expenditures in real terms for Japan, the United States, Germany and France are calculated using the amount in 1985 as the basis of comparison. According to this data, Japan has the highest growth rate among these nations (Figure 2-1-2).

1) In this paper, "research activities" apply only to natural sciences and not to social sciences and humanities. Classification of natural sciences as distinct from social sciences and humanities is based on the individual research institute or university and college department concerned.
2) R&D expenditures are the funds spent by research institutions themselves for research. There are two methods of estimating R&D expenditures: disbursement and cost. This paper considers R&D expenditures to be disbursements. Disbursement includes expenditures on labor, materials, tangible fixed assets, and so on. In case of cost, it is computed by adding the depreciation of tangible fixed asset instead of expenditure on the tangible fixed assets.
Japanese R&D expenditures are calculated for Japan's fiscal year, which begins in April.
3) In Part 2, data for Germany covers West Germany only.

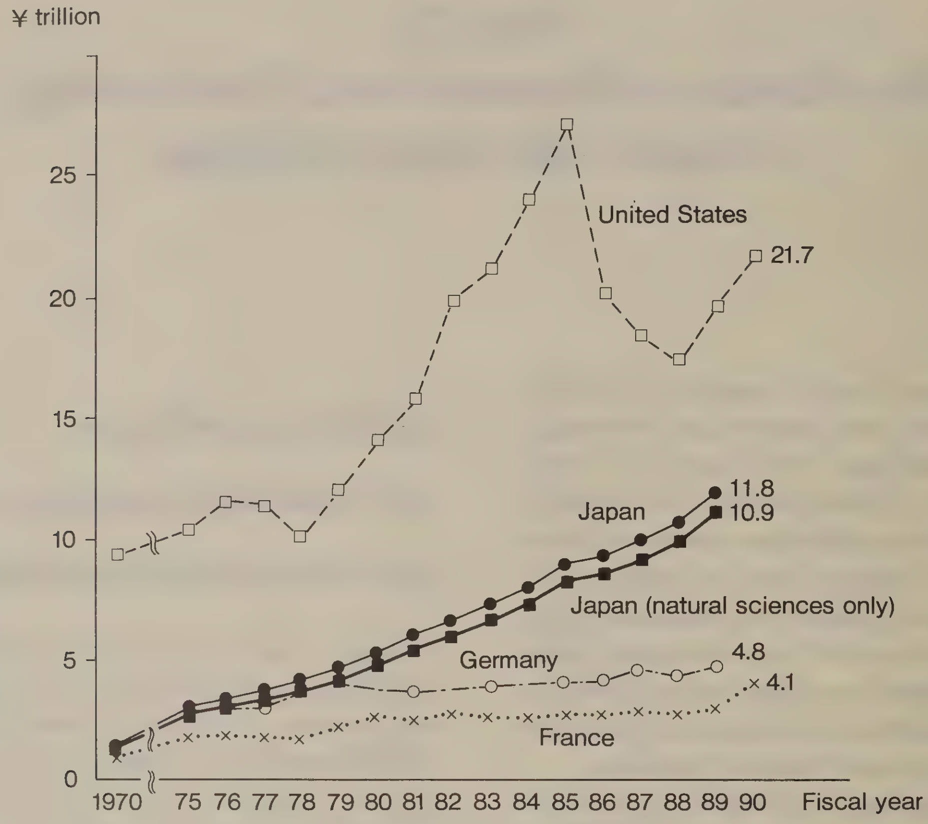


Figure 2-1-1(1). Trends in R&D expenditures of selected countries - IMF exchange rate conversion

2.1.1.3. R&D Expenditures as a Percentage of Gross National Product (GNP)

R&D expenditures as a percentage of GNP show the level of research investment. During the 1970s, this percentage decreased or remained level worldwide. It began to increase in 1978 and has grown steadily since then, although the United States' percentage has been decreasing slightly in recent years. Japan has increased its ratio significantly. In FY1989 it became 2.91% including social sciences and humanities (2.69% for natural sciences only) (Figure 2-1-3).

The Council for Science and Technology (CST) in its Recommendation on Inquiry No. 11 Long-range General Basic Policies on Science and Technology Reflecting Current Developments stated that the first goal is to secure 3% of the national income (NI) for R&D expenditures in natural sciences, with the long-term goal of 3.5%.

The first goal of 3% was achieved in FY1985; the percentage was 3.43% in FY1989. The focus now is on a time frame for achieving the latter goal. This growth has resulted from Japan's recognition of the importance of science and technology development in adverse circumstances at home and abroad. Investment in R&D by the private sector has contributed greatly to R&D activities in Japan.

4) In this paper, whenever R&D expenditures and number of researchers are discussed, they refer to both national government and local government.

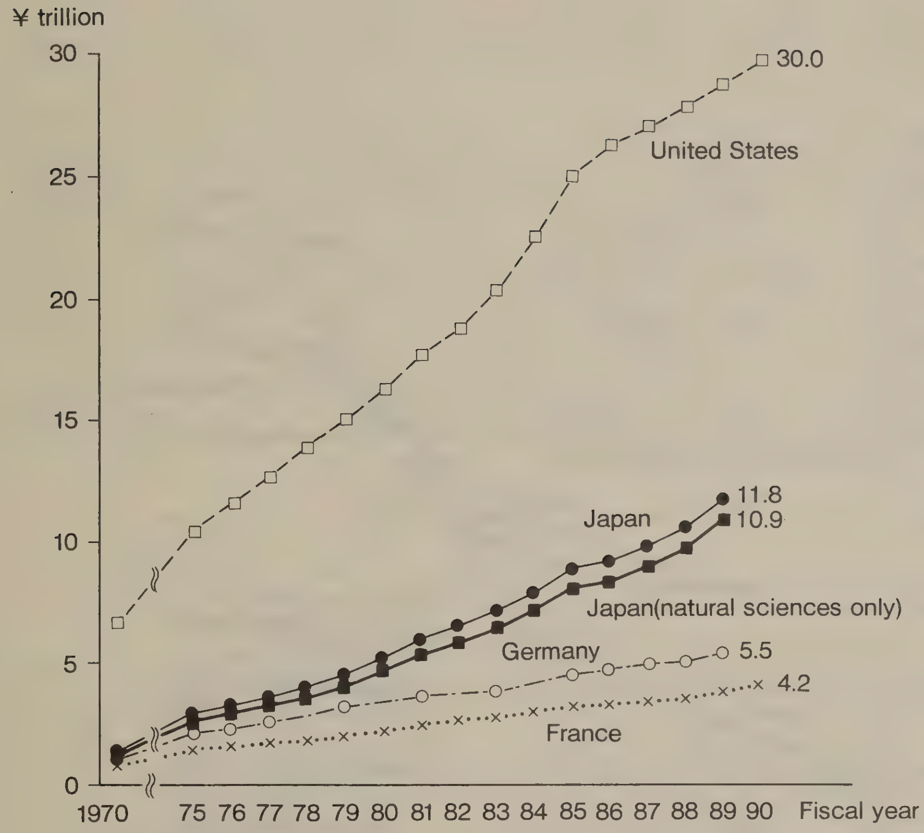
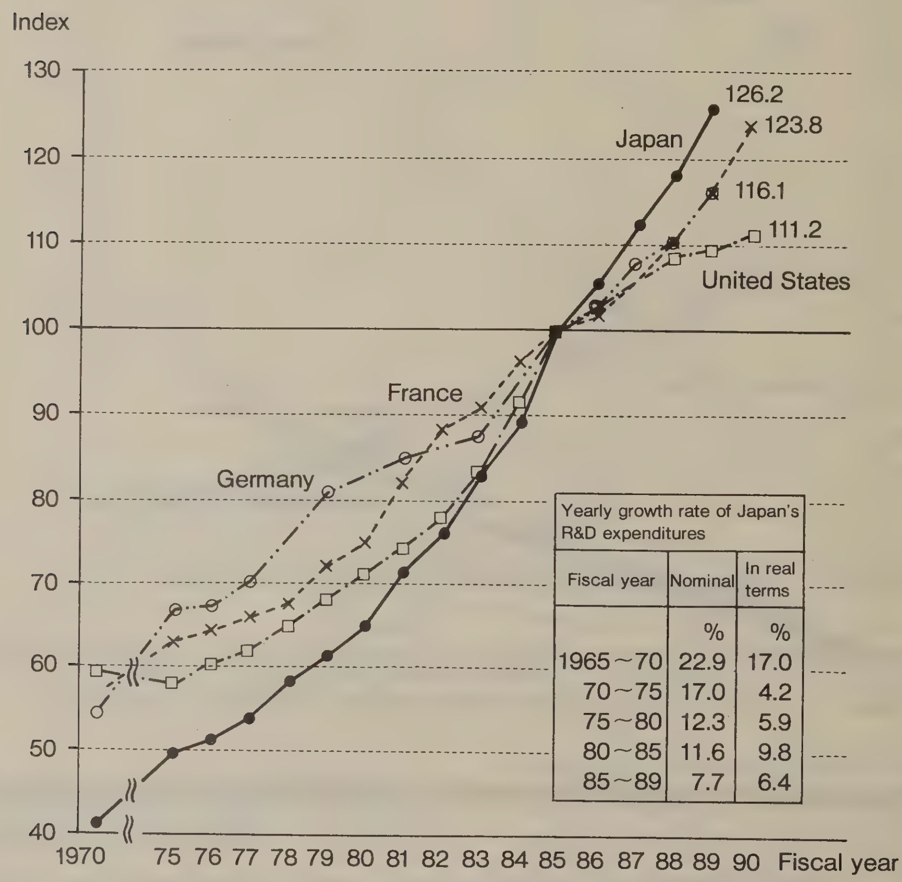


Figure 2-1-1(2). Trends in R&D expenditures of selected countries - OECD purchas ing power parity

Note: 1. For comparison, statistics for all countries include research in social sciences and humanities. The figure for Japan show also the amount for natural sciences only.
2. Only the figures for Japan are not on a full-time equivalent basis.
3. The 1989 data for the US are provisional and the 1990 data are estimate.
4. Germany: the years for which data are not available are indicated on a straight line.
5. The 1989 and 1990 data for France are provisional.
6. The United Kingdom's R&D expenditures for 1988 are 2.36 trillion yen (IMF exchange rate conversion) and 3.54 trillion yen (Purchas ing power parity, Cabinet Office, Annual Review of Government Funded R&D).

Source: Japan — "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency
US — "National Patterns of R&D Resources" by National Science Foundation (NSF)
Germany — "Bundesbericht Forschung", "Faktenbericht zum Bundesbericht Forschung" by Federal Ministry forResearch and Technology (BMFT)
France — Projet de Loi de Finances--Rapport annexe sur l'Etat de la Recherche et du Developpement Technologique. OECD statistics for the 1990 data.

(See Appendix 1)



Yearly growth rate of Japan's R&D expenditures

Fiscal year	Nominal	In real terms
	%	%
1965~70	22.9	17.0
70~75	17.0	4.2
75~80	12.3	5.9
80~85	11.6	9.8
85~89	7.7	6.4

Figure 2-1-2. Growth of R&D expenditures (in real terms) in selected countries

Note: 1. For comparison, statistics for all countries include research in social sciences and humanities. The table in the figure on Yearly Growth Rate of Japanese R&D expenditures represents only that for natural sciences.
2. The 1985 index is set at 100.
3. The 1989 data for the US are provisional, the 1990 data are an estimated.
4. Germany: the years for which data are not available are indicated on a straight line.
5. The 1989 and 1990 data for France are provisional.

Source: Same as in Figure 2-1-1.
(See Appendix 1, 15)

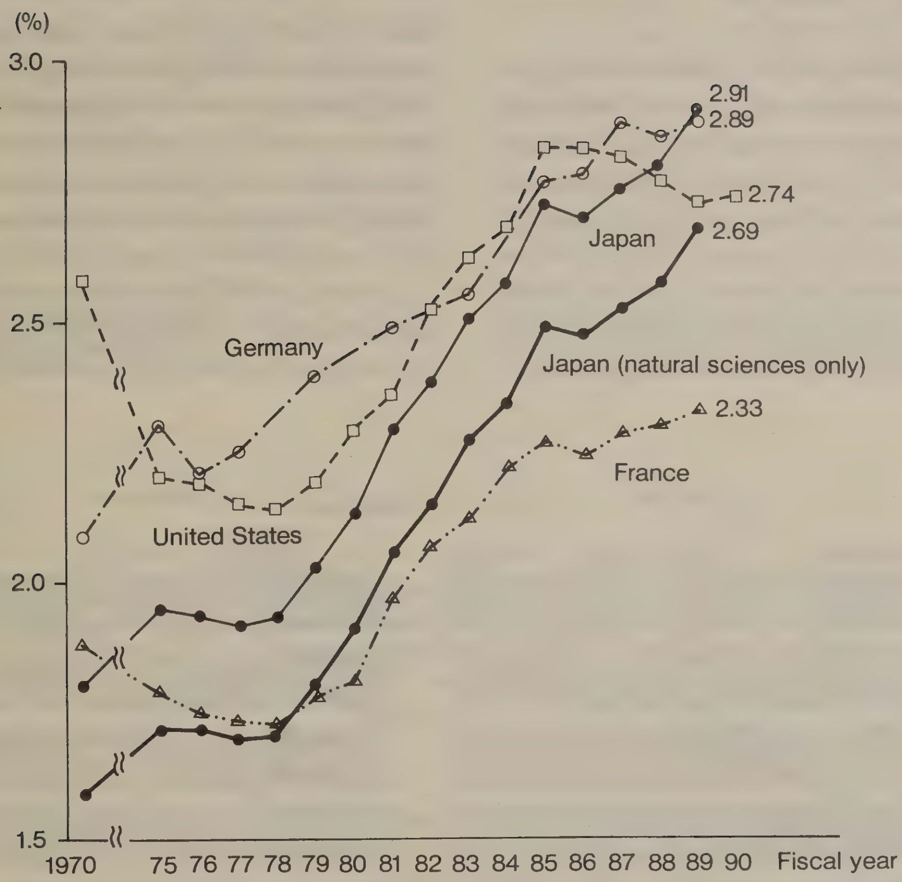


Figure 2-1-3. R&D expenditures as a percentage of GNP in selected countries

Note: 1. For comparison, statistics for all countries include research in social sciences and humanities. The figures for Japan show also the amount for natural sciences only.
2. Only the figures for Japan are not on a full-time equivalent basis.
3. The 1989 data for the US are provisional and the 1990 data are estimated.
4. Germany: the years for which data are is not available are indicated on a straight line.
5. French data for 1989 are provisional.
6. The 1987 and 1988 data for the United Kingdom are 2.22% and 2.19%, respectively.

Source: Same as in Figure 2-1-1.
(See Appendix 1)

2.1.2. R&D Expenditures by Financing and Performance Sector

2.1.2.1. Share of R&D Expenditures by Financing and Performance

R&D expenditures can be characterized by the financing and performance aspects of categorized sectors. The statistics compiled by the Organization for Economic Cooperation and Development (OECD) categorize sectors into government[4], industry, universities and colleges, private research institutions, and abroad. Shares of R&D expenditures by financing and performance in selected countries are compared by OECD - categorized sectors.

The government R&D expenditures percentage may differ from country to country due to differences in defense-related research, tax structure, activities in the private sector etc. Generally speaking, in terms of the government share of R&D expenditures financing, France is ranked first at 50%, followed by the United States at 46% and the United Kingdom at 37%. Japan's share is a mere 19% including social sciences and humanities or 17% for natural sciences only. In Japan the private sector finances a great deal of R&D expenditures Figure 2-1-4(1)).

Looking at R&D performance, industry spends approximately two-thirds of the total R&D expenditures in selected countries. This means

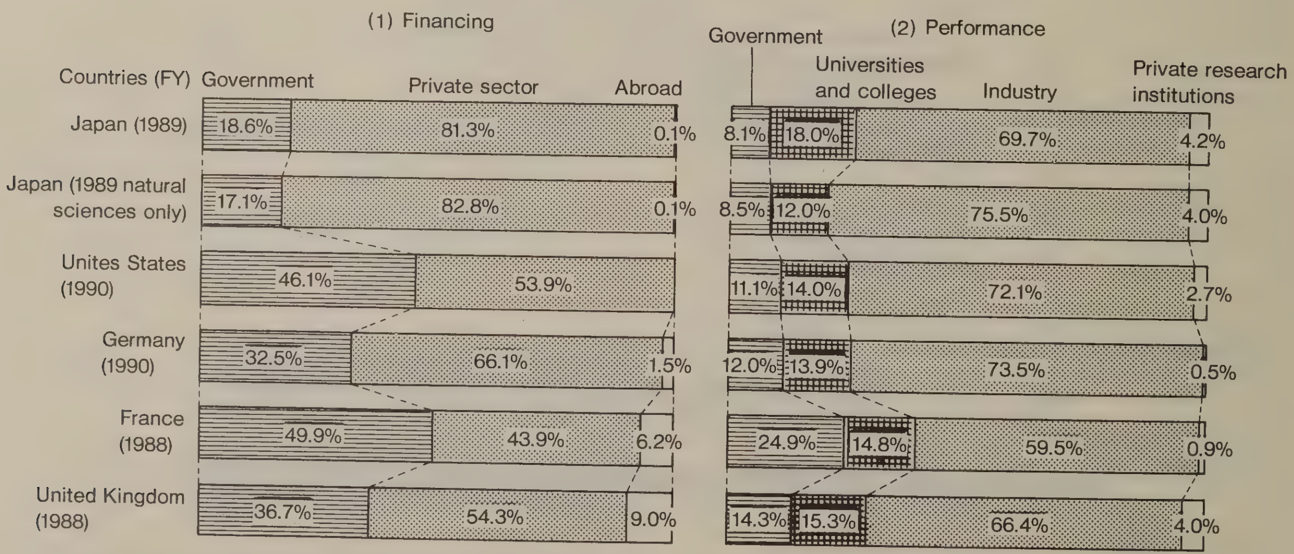


Figure 2-1-4. Share of R&D expenditures financing and performance sector in selected countries

Note: 1. For comparison, statistics for all countries include research in social sciences and humanities. The figures for Japan show also the amount for natural sciences only.

2. (1) In the financing column, the private sector includes any sector other than the government and abroad.

3. (2) Government in the performance column means government research institution as defined by the OECD.

Source: Japan and US — Same as in Figure 2-1-1.
Germany and France — OECD statistics
United Kingdom — "Annual Review of Government Funded R&D" by Cabinet Office
(See Appendix 2, 5)

that private companies play a big role in performing R&D. The government share of R&D performance is at 25% in France and 14% in the United Kingdom, both of which have higher ratios than Japan and the United States (Figure 2-1-4(2)).

An analysis of the trends in the share of R&D expenditures financed by government shows a long-term decline in every country, though the curve seems to be leveling off in the United States. This is due to increased activities by the industry sector and its increased relative importance in every country. Excluding the defense-related R&D budget, where a major difference between Japan and other countries exists, the government shares of R&D financing were 34% in France, 30% in Germany and 26% in the United States.

In contrast, the Japanese government's share of R&D financing outside the defense-related R&D budget is mere 18%(including social sciences and humanities), or 16% for natural sciences only (Figure 2-1-5).

Comparing flows of R&D expenditures bet-

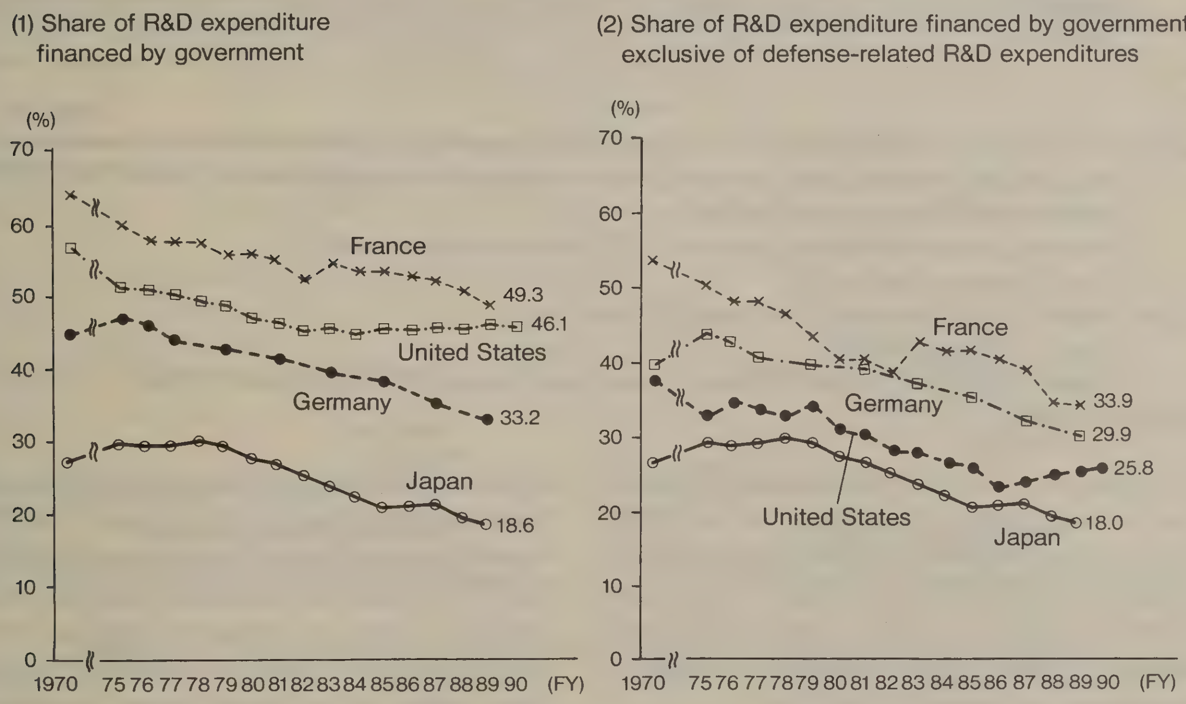


Figure 2-1-5. Trends in government-financed for R&D expenditures in selected countries

Note: 1. For comparison, statistics for all countries include research in social sciences and humanities.
2. Government percentages exclusive of defense-related research expenditures are calculated by the following equation.

$$\frac{\text{(Government financed R\&D expenditures)} - \text{(Defense - related R\&D expenditures)}}{\text{(R\&D expenditures)} - \text{(Defense - related R\&D expenditures)}} \times 100(\%)$$

3. The 1989 data for the U.S. are provisional and the 1990 data are an estimated.
4. The defense-related R&D expenditures for Germany in 1989 are provisional.
5. Germany: the years for which data are not available are indicated on a straight line.
6. The 1989 and 1990 data for France are provisional.

Source: Same as in Figure 2-1-1.
(See Appendix 1)

Table 2-1-6. The flows of R&D funds between industry, universities and colleges, and government sectors in selected countries

Financing sector	Performing sector	Japan (1989)		United States (1990)		Germany (1989)		France (1983)		United Kingdom (1988)	
		Amount Unit ¥100 Mil	Share %	Amount Unit ¥100 Mil	Share %	Amount Unit ¥100 Mil	Share %	Amount Unit ¥100 Mil	Share %	Amount Unit ¥100 Mil	Share %
Government	Government	8,827	92.6	33,400	100.0	6,590	92.7	7,227	95.6	4,278	84.2
Industry	Government	707	7.4	0	0	393	5.5	52	0.7	472	9.3
Government	Industry	1,028	1.2	71,300	33.0	4,526	11.5	3,646	22.4	3,888	16.5
Industry	Industry	81,161	98.6	145,000	67.0	34,771	86.8	11,867	73.0	16,799	71.4
Government	Universities and Colleges	10,921	51.3	28,860	68.6	7,115	92.5	4,424	97.6	4,222	77.9
Industry	Universities and Colleges	458	2.2	2,300	5.5	575	7.5	58	1.3	322	5.9

Note: 1. For comparison, statistics for all countries include research in social sciences and humanities.
2. Percentages show the share of the R&D expenditures of financing by sector against the total R&D expenditures of performance by sector.
3. The amounts are converted based on OECD purchase power parity.
4. The U.S. data are estimated.

Source: Japan, US and Germany - Same as in Figure 2-1-1.
France - OECD statistics
United Kingdom - "Annual Review of Government Funded R&D" by Cabinet Office
(See Appendix 2)

ween financing and performance sectors shows that in Japan there is a lesser flow of R&D expenditures between sectors (government, industry, universities and colleges) than exists in other countries and that in the Unites States the ratio of industry R&D expenditure funded by government is greatest (Table 2-1-6).

In Japan, industry performs little of government-financed R&D. This is because, in Japan, each sector has been rather independent from one another, and has had little interaction. Furthermore, Japan's private sector is quite active in R&D. Another reason is, for example, in the United States, the flow of defense-related R&D expenditures between sectors is very high.

2.1.2.2. R&D Expenditures by Sector

R&D expenditures are increasing in major countries. The rate of increase of R&D expenditures in real terms by sector shows that R&D expenditures performed by industry are increasing. This indicates that R&D activity in the industrial sector have become brisk in recent years. The rate of increase is especially high in Japan, while in the United States it is slowing down. R&D expenditures for government research institutions and universities and colleges are increasing, though the increase is not as high as that of industry. Among these countries the increase in R&D expenditures by government research institutions in France is relatively high (Figure 2-1-7).

Industry has a great influence on growth of R&D expenditures. Particularly in Japan, the growth of R&D expenditures has been influenced by trends in R&D expenditures by companies. Examining changes in the contribution by

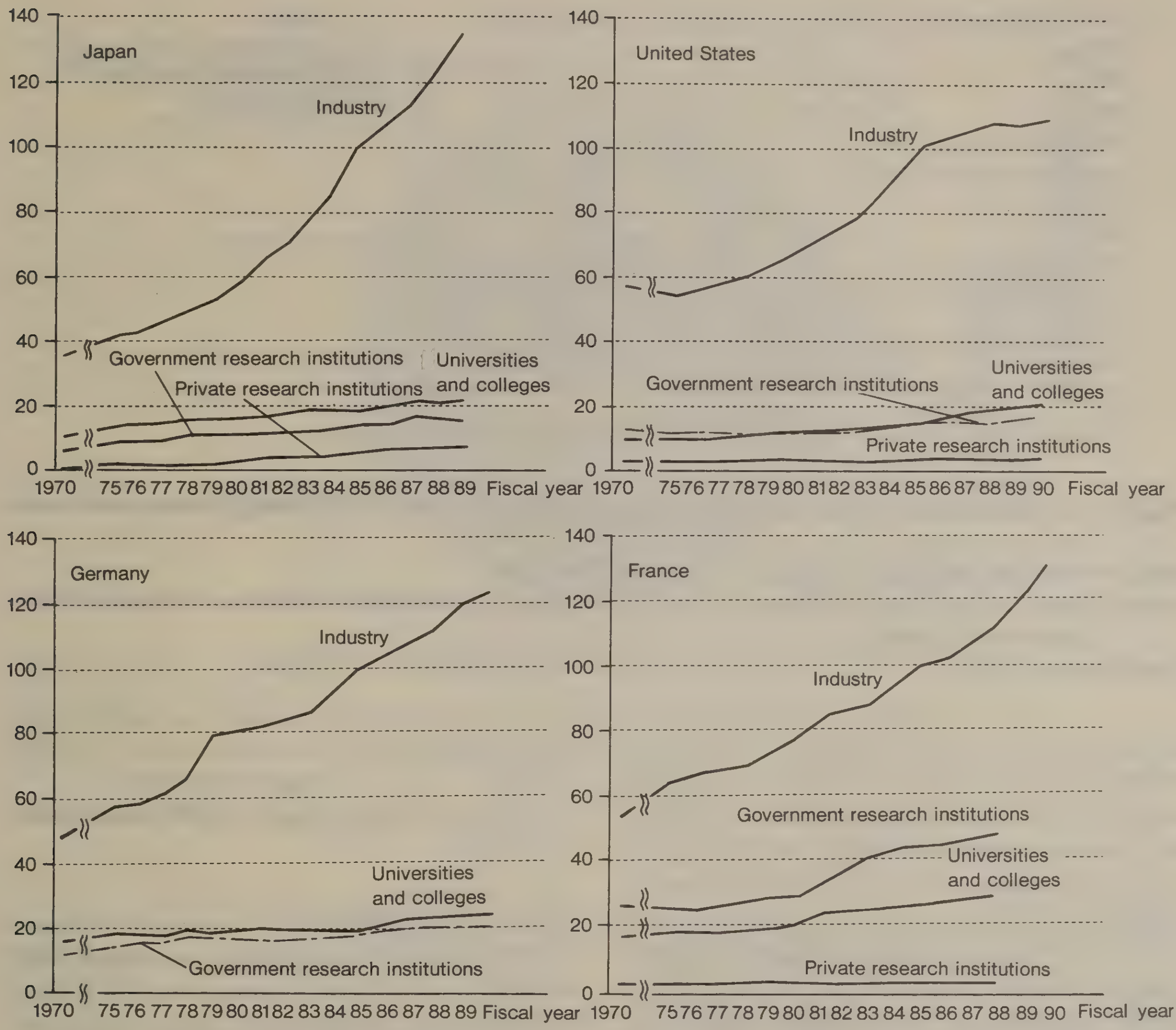


Figure 2-1-7. R&D expenditure growth (in real terms) by sector in selected countries

Note: 1. The index in FY1985 is set at 100 in each country. This is equivalent to R&D expenditures (in real terms) by industry in that year.
2. All countries except Japan include social sciences and humanities.
3. The 1989 data for the US are provisional and the 1990 data are an estimated.
4. Germany: the years for which data are not available are indicated by a straight line.
5. The 1989 and 1990 data for France are provisional.

Source: Japan and US - Same as in Figure 2-1-1.
Germany and France - OECD statistics
(See Appendix 5, 15)

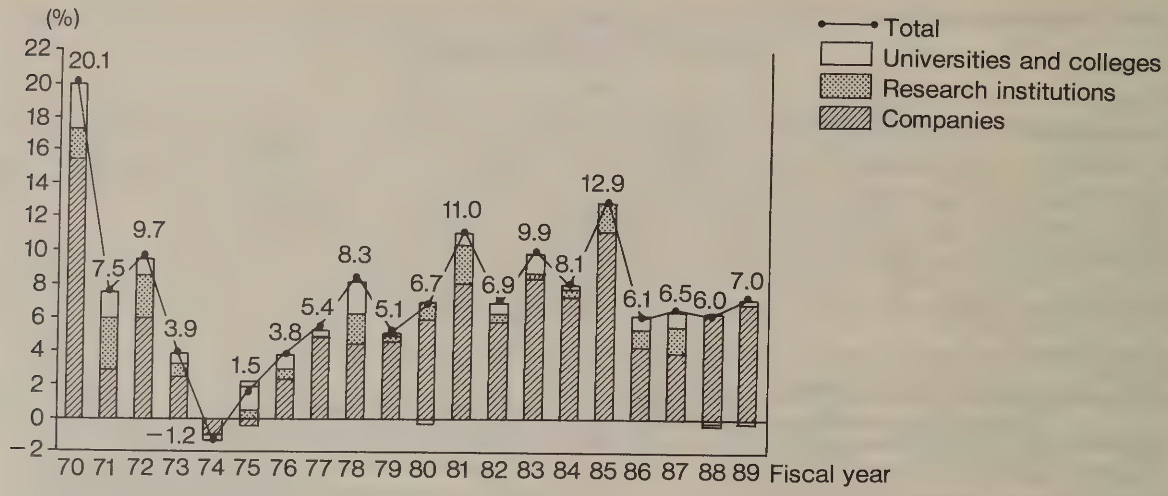


Figure 2-1-8. Contributions by sectors to the annual increases of Japan's R&D expenditures in real terms

Note: The deflation raterring for each sector is based on FY1985.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency
(See Appendix 5, 15)

sectors to the annual increases of Japan's R&D expenditures in real terms, from the early 1970s the economy began stagnating and this, along with the oil crisis, caused in FY1974 a decrease of R&D expenditures in real terms. As a result, total R&D expenditures compared to the previous year also dropped. From the late 1970s, R&D expenditures by industry started to increase, and along with this, R&D expenditures for the entire nation have steadily risen (Figure 2-1-8).

This section gives Japan's R&D expenditures by sector.[5)]

2.1.2.2.1. Companies

In Japan, 14,700 companies conducted R&D activities in FY1989. Among them, 87.7% are manufacturing companies; 11.0% are in construction. Among the manufacturing companies, the general machinery industry with 16.4%, the

5) Research activities in Japan in this paper are provided by companies, research institutions, and universities and colleges. These classifications are based on the "Report on the Survey of Research and Development" compiled by the Statistics Bureau, Management and Coordination Agency. The Following defines some of these organizations.

- Companies-Corporate companies (Capital: 1 million yen or more (FY1974 or before), Capital: 300 million yen or more (between FY1975 and FY1978), Capital: 5 million yen or more (FY1979 or after), and profit-oriented public corporations (such as NHK (the Japan Broadcasting Corporation), and the Japan Highway Public Corporation).
- Research institutions-National, local government-owned and private (such as foundations) research institutions and research-centered public corporations. Research-centered public corporations are, for example, the National Space Development Agency of Japan, the Power Reactor and Nuclear Fuel Development Corporation, the Japan Atomic Energy Research Institute and the Institute of Physical and Chemical Research. According to the OECD definition, government research institutions include national and local government-owned research institutions and research-centered public corporations.
- Universities and colleges-Departments of universities and colleges (including graduate schools), junior colleges, collges of technology, research institutions attached to the universities and colleges and inter-university research institutes, and the National Center for University Entrance Examinations.

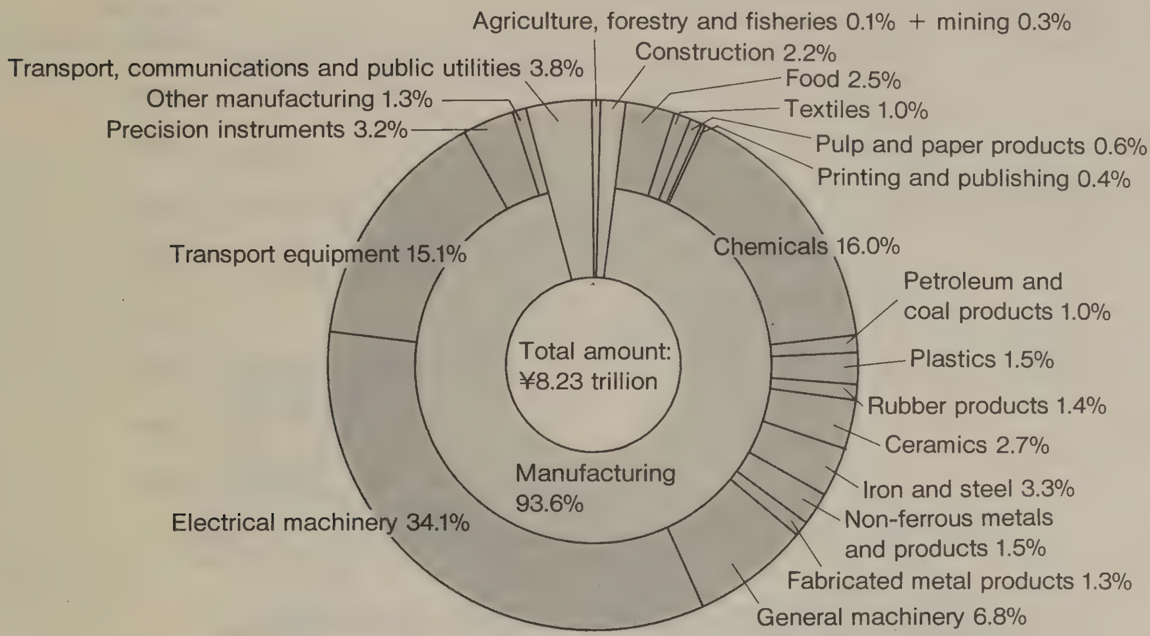


Figure 2-1-9. R&D expenditures by industry (FY1989: 8.23 trillion)

Note: Figures are their shares in percentages to total companies R&D expenditures
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency
(See Appendix 9)

electrical machinery industry with 13.6%, and the chemical industry with 11.1%contain the largest shares.

R&D expenditures by companies have been increasing rapidly; their average annual rate has been 9.0% in real terms for the 5 years from FY1984 to FY1989. In FY1989, the increase over the previous year was 14.1%(9.5% in real terms). R&D expenditures then totaled 8,233.8 billion yen, 75.5% of the total R&D expenditures in Japan.

R&D expenditures by industry type show manufacturing at 93.6% followed by transportation/communication/public utilities companies at 3.8%. In the manufacturing category, the electric machinery industry accounts for 34.1%, chemicals for 16.0% and the transport equipment for 15.1% of the total industrial R&D expenditures. These three types of industries perform 65.2% of the total industrial R&D expenditures (Figure 2-1-9).

The average annual rates of increase between FY1984 and FY1989 in these three industry sectors were 11.4%(10.5 in real terms) in electrical machinery, 9.0%(8.2 %)in chemicals, and 9.0%(8.1%) in transport equipment.

Adopting the ratio of R&D expenditures against total sales as the index that indicates a company's awareness of the importance of R&D and examining changes in that ratio, we see the ratio increasing in major industries. In FY1989, the ratio of R&D expenditures to sales was 2.72% in all industries, and was the highest in Japan's history. This indicates that the relative importance of R&D is increasing in companies along with the trend toward high-tech products, etc. Principal industries with a high R&D to sales ratio are electrical machinery (5.89%), precision

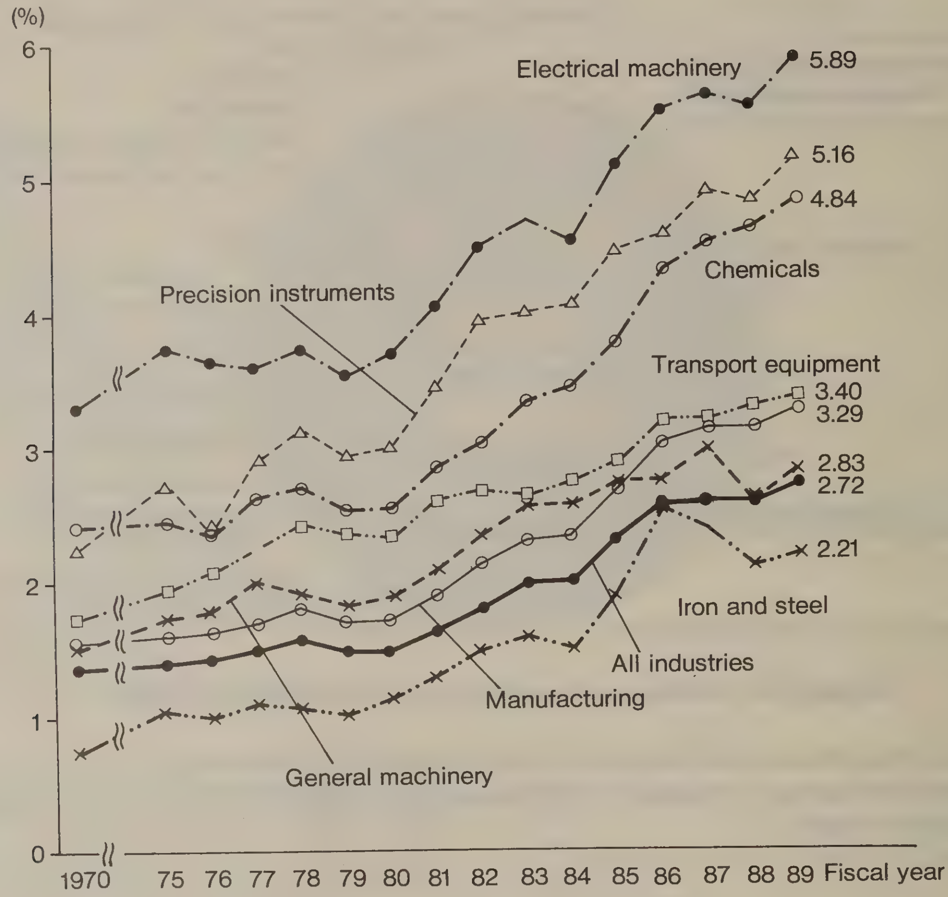


Figure 2-1-10. Ratio of R&D expenditures to sales figures in selected industries

Note: Figures are for private companies only. Public corporations are not included.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency
(See Appendix 10)

instruments (5.16%), and chemicals (4.84%) (Figure 2-1-10).

2.1.2.2.2. Research Institutions

Research institutions in Japan may be classified as national, local government-owned, private including nonprofit organizations such as foundations, and research-centered public corporations.

National and local government-owned research institutions and public corporations are conducting research necessary to implement policies in the following fields.

- Basic and leading research
- Large-scale research such as nuclear energy development and space development
- Research to secure resources such as food and energy
- Research to support small-to-medium-sized enterprises
- Research to promote significant local industries for the development of the local economy
- Research that is beyond the capabilities of the

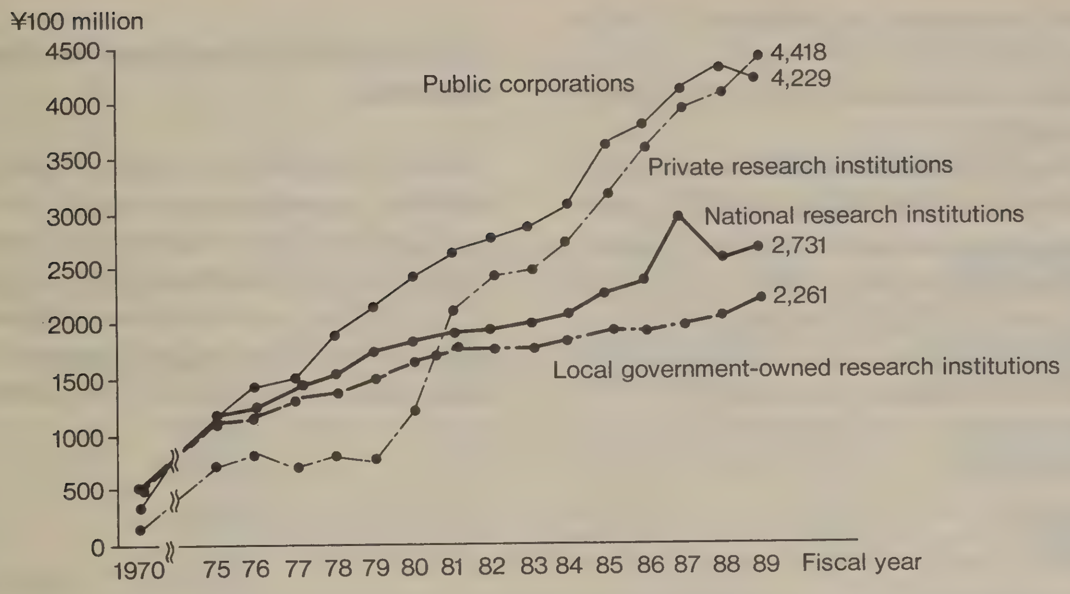


Figure 2-1-11. Trends in R&D expenditures by research institution

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency
(See Appendix 5)

private sector

The R&D expenditures by research institutions in Japan for FY1989 were 1,363.9 billion yen. (The average annual rate of increase in real terms between FY1984 and FY1989 was 5.8%.) This was 12.5% of the nation's total R&D expenditures. The government provides most of the R&D funds for national and local government-owned research institutions and public corporations and 25.8% of the R&D funds to private sector research institutions. As a result, the government provides 70.8% of the total funds for research institutions.

R&D expenditures by organizations in FY1989 were as follows: (Figure 2-1-11)

- National research institutions: 273.1 billion yen (20.0% of total for research institutions)
- Local government-owned research institutions: 226.1 billion yen (16.6%)
- Private research institutions: 441.8 billion yen (32.4%)
- Research-centered public corporations: 422.9 billion yen (31.0%)

2.1.2.2.3. Universities and Colleges

The universities and colleges, as institutions of higher education, have an important role in cultivating research personnel while at the same time carrying out a broad area of research activities, especially basic research, to search for the truth.

The universities and colleges R&D expenditures in FY1989 were 1,311.6 billion yen, which was 12.0% of the total R&D expenditures for the nation. (The average annual rate of increase from FY1984 to FY1989 was 2.4% in real terms). More than half of the R&D expenditures by universities and colleges are disbursed by national universities and colleges.

- National universities and colleges: 705.5 billion yen (53.8% of total for universities and colleges)

- Public universities and colleges: 74.3 billion yen (5.7%)
- Private universities and colleges: 531.9 billion yen (40.5%)

Viewing the R&D expenditures by field (by university and college department), the health and engineering shares were relatively large.

- Physical sciences: 187.0 billion yen (14.3%)
- Engineering: 481.8 billion yen (36.7%)
- Agricultural sciences: 99.8 billion yen (7.6%)
- Health: 543.0 billion yen (41.4%)

2.1.2.3. R&D Expenditures by Consisting Elements

R&D expenditures consist of labor costs, materials, expenditures on tangible fixed assets (land and buildings, machinery, instruments, equipment, and others) and other expenses.

The changes in the breakdown of Japan's R&D expenditures by consisting elements show that labor costs are consistently the highest every

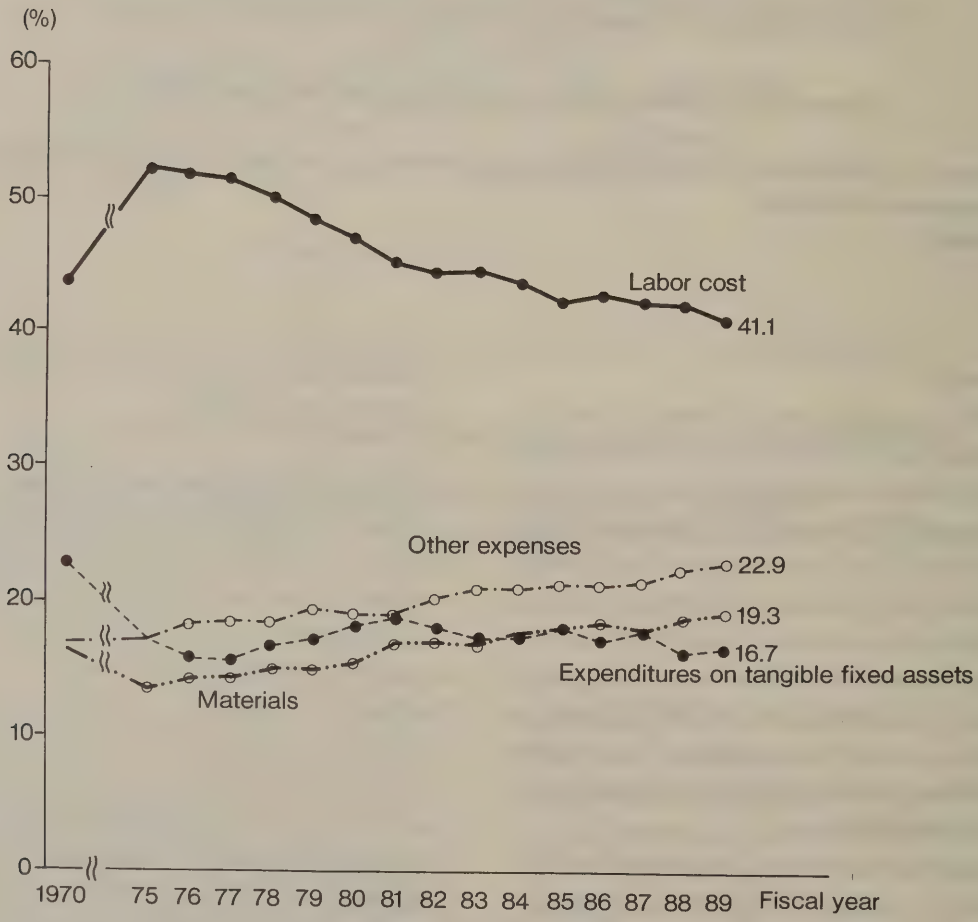


Figure 2-1-12. Trends in R&D expenditures by consisting elements

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency
(See Appendix 6)

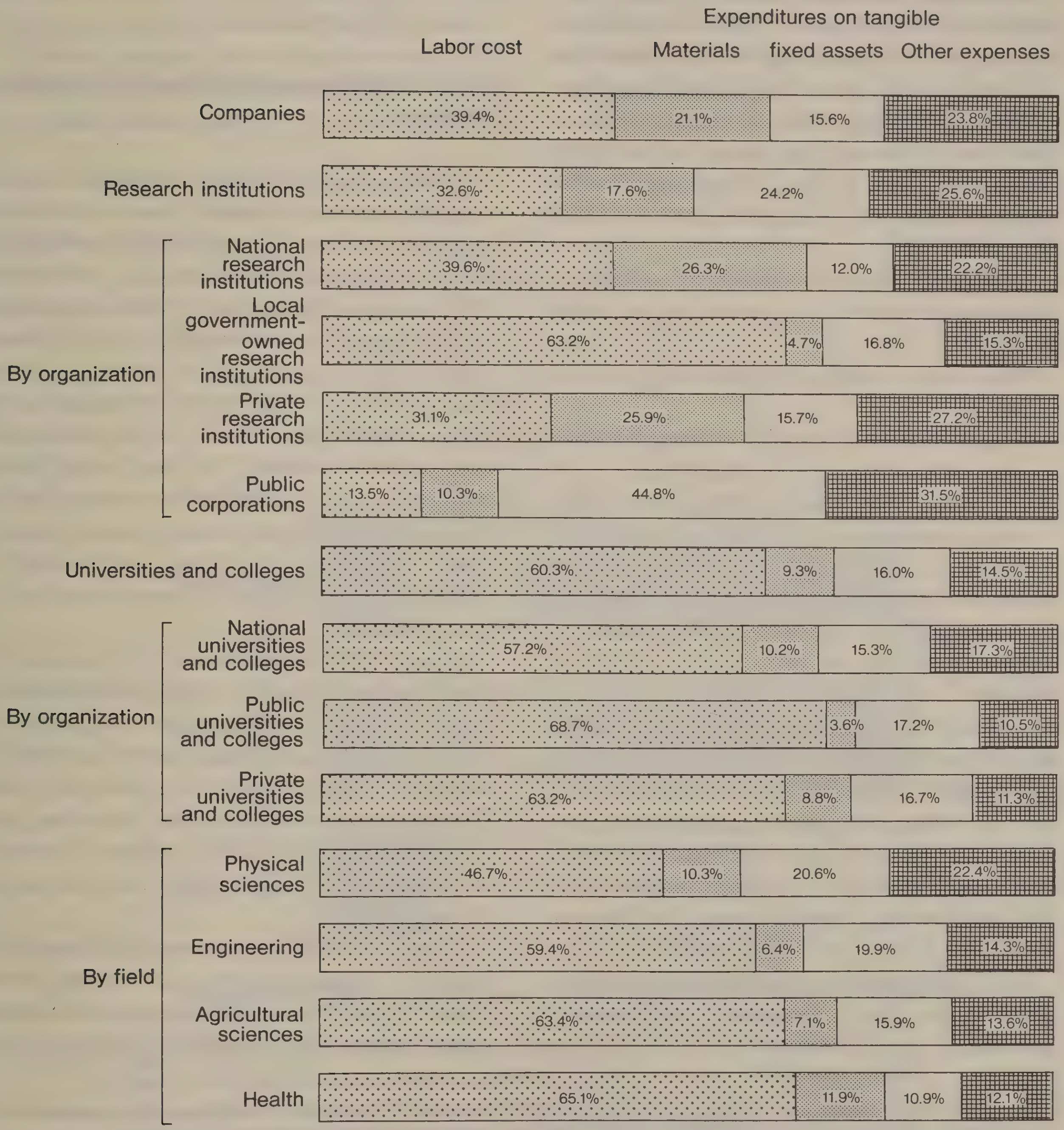


Figure 2-1-13. R&D expenditures by sector and by consisting elements, FY1989

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency
(See Appendix 6)

year. In the early 1970s, labor costs tended to increase. However since FY1975, they have been decreasing, accounting for 41.1% in FY1989. Material costs have been increasing slightly, and accounted for 19.3% in FY1989. Expenditures on tangible fixed assets were 16.7%. Other costs, including hire for research equipment, purchases of books, office supplies and communications, have been increasing, and accounted for 22.9% in FY1989. This is due to increased fees for leasing mainframe computers used for R&D (Figure 2-1-12).

Comparing costs of research by sector, the following distinctive tendencies can be recognized.

- The ratio of material costs is high in companies.
- The ratio of expenditures on tangible fixed assets is high in research institutions.
- The ratio of labor costs is high in universities and colleges.

Labor costs in companies R&D tended to increase from FY1970, and attained 51.9% of total expenditures in FY1976. They tended to decline, breaking the 40% level at 39.4% by FY1989.

A look at research institutions by organization shows that the ratio of labor costs in local government-owned research institutions is high. On the other hand, public corporations have higher expenditures for the purchase of tangible fixed assets and other expenses, because they include those requiring large-scale facilities and equipment for nuclear and space R&D.

Universities and colleges have higher ratios of labor costs than companies and research institutions. In FY1989, university and college ratios of labor costs were 60.3%. This was 68.7% for public universities and colleges. By field, physical sciences have lower ratios of labor costs than the average ratio in universities and colleges (Figure 2-1-13).

2.1.3. R&D Expenditures by Character of Work

Classification into basic research, applied research and development[6], may differ from country to country. However R&D expenditure data by character of work generally reflects the R&D activity of each country. Recent statistical data for Japan, the United States, and Germany shows that Germany spends more on basic research. The composition of R&D is similar in Japan and the United States, with a little higher ratio of basic research for the United States (Figure 2-1-14). Examining basic research ratios of Japan and the United States by sector, Japan's ratio in industry is higher, while that in universities and colleges is lower, than in the United States.

Japan's R&D expenditures by character of work among companies, research institutions, and universities and colleges are distinctly different. Companies spend more on development due to the nature of corporate activities. Universities and colleges spend more than half of their expenditures on basic research. Research institutions fall between the two categories (Figures 2-1-15).

Changes in R&D expenditures by character of work for companies showed the following trend. From the late 1960s, the ratio of basic and applied research decreased while that of development

6) Report of the survey of Research and Development compiled by the Statistics Bureau, Management and Coordination Agency defines classification of research by character of work as follows.
- Basic research: research undertaken primarily for the advancement of scientific knowledge, where a specific practical application may be indirectly sought.
- Applied research: research undertaken primarily for the advancement of scientific knowledge, with a specific practical application sought directly.
- Development: the use of available knowledge obtained as the result of basic and applied research and/or practical experience which is directed to the introduction of new material, equipment, products, systems and processes, etc. or the improvement of such already available.

increased. However, from the early 1980s, the ratio of basic research started to increase, accounting for 6.4% of total R&D expenditures in FY1989, while applied research accounted for 21.5% and development was 72.2%.

A look at research institutions by organization shows that national research institutions conduct more basic research and local government-owned research institutions conduct more applied research. Public corporations conduct an especially large amount of development.

Looking at universities and colleges by field, more basic research is conducted in the physical sciences and more applied research is conducted in the health fields.

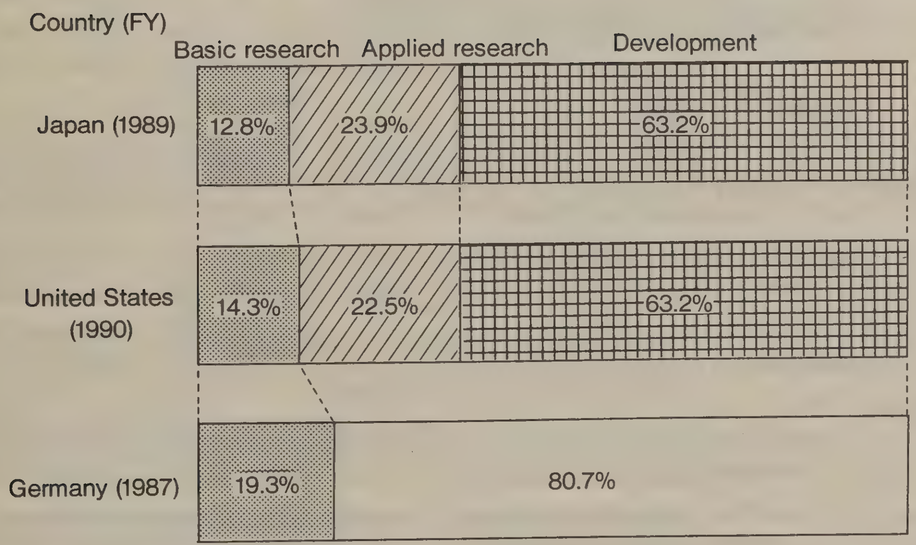


Figure 2-1-14. R&D expenditures by character of work in selected countries

Note: 1. Figures for the United States are estimated.
2. There is no distinction in Germany between applied research and development.

Source: Japan and U.S. - Same as in Figure 2-1-1.
Germany - "Statistics on Science and Technology" by UNESCO.

(See Appendix 3)

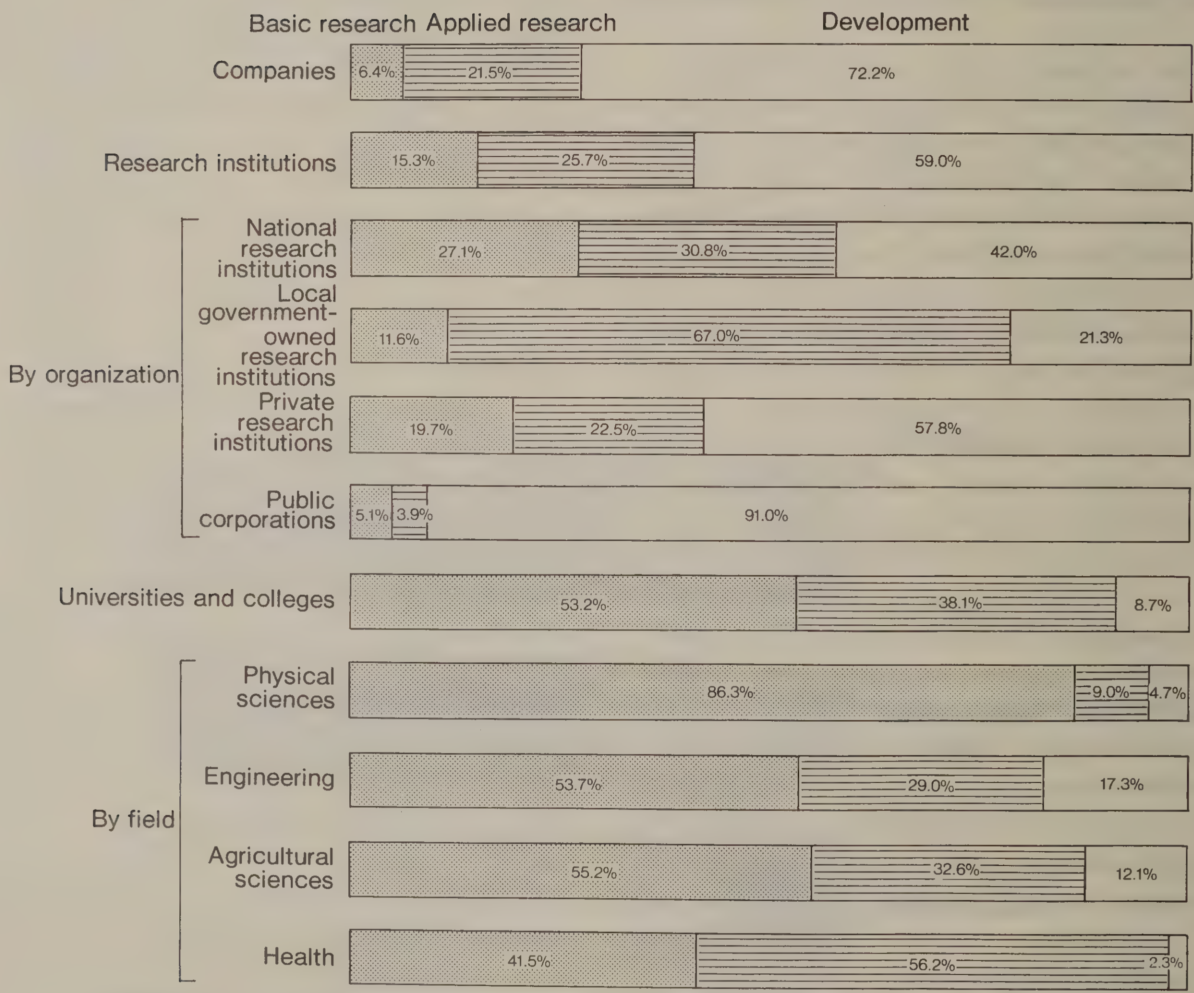


Figure 2-1-15. Composition of R&D expenditures by character of work by sector

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency
(See Appendix 3)

2.2. Research Personnel

Statistics on research personnel, along with those on R&D expenditures, is another effective indicator of the extent of research activities. Personnel engaged in R&D[7] can be classified as researchers and support personnel (assistant research workers, technicians, and clerical and other supporting personnel).

2.2.1. Researchers

2.2.1.1. Number of Researchers

Countries use different methods for determining the number of researchers. As a result, simple comparisons may not be precise. It is useful, however, to look at general trends for each country from its own statistics. In 1988, the United States had 949,000 researchers, about twice as many as did Japan. Both Germany and France had fewer researchers than Japan. During the last 10 years the number of researchers in Japan and the United States has increased substantially (Figure 2-2-1).

Looking at the changes in the number of researchers in Japan, in 1990 the number of researchers was 484,000 (560,000 including social sciences and humanities). It was 462,000 in the previous year (535,000 including social sciences and humanities). This was a 4.9% increase (4.7% including social sciences and humanities) over the previous year.

The average annual rates of increase are as follows.

- 1965 - 1970 : 7.9%
- 1970 - 1975 : 8.2%
- 1975 - 1980 : 3.5%
- 1980 - 1985 : 4.7%
- 1985 - 1990 : 4.9%

The percentage slowed down in the late 1970s, though from the late 1980s the rate has increased steadily.

2.2.1.2. Number of Researchers per 10,000 Population and per 10,000 Labor Force

Japan has the highest number of researchers per 10,000 population and per 10,000 labor force, exceeding even the United States (Figure 2-2-2).

2.2.1.3. Number of researchers by sector

The number of researchers by sector in Japan is as follows:

- Industry: 314,000 (64.8%)
- Universities and colleges: 134,000 (27.7%)
- Government research institutions (including public corporations): 27,000 (5.6%)

The United States has a greater percentage of researchers working in industry, and the percentage of researchers in its government research institutions is low, similar to Japan. The ratio of researchers at universities and colleges in the United States is also low. The ratio of government researchers in Germany is higher than that of Japan and the U.S., and the ratio in industry is also higher than Japan. The ratio of researchers in industry in France is low, as

7) "Report on the Survey of Research and Development", compiled by the Statistics Bureau, Management and Coordination Agency Classifies personnel engaged in R&D as follows.
Researcher: Persons who hold a university degree (or persons who have equivalent or greater knowledge in ther specialty), who have research experience of at least two years, and who are engaged in research activities in their own chosen subject.
Assistant research workers: persons who assist researchers and who are engaged in research activities under their direction and who have the possibility of becoming researchers in the future.
Technicians: Persons, other than researchers and assistant research workers, who are engaged in technical services related to research acitvities under the guidance and supervision of researchers and assistant research workers.
Clerical and other supporting personnel: Excepting those mentioned above, persons who are engaged in miscellaneous activities, clerical work, accounting, etc. relating to research activities.
Japanese statistics on persons engaged in R&D are as of April 1 of the appropriate year.

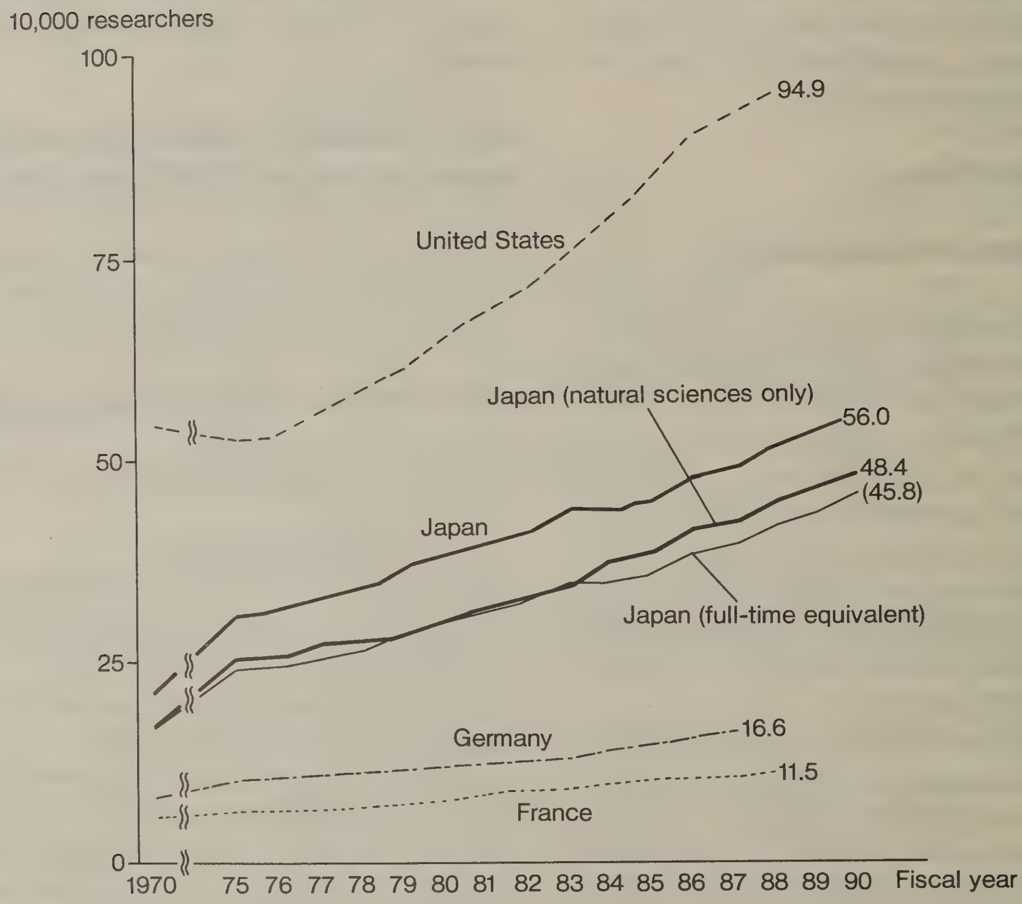


Figure 2-2-1. Trends in number of researchers in selected countries

Note: 1. The figures for all countries include social sciences and humanities. The statistics for Japan also show numbers for researchers in natural sciences only.

2. Only the figures for Japan are not on a full-time equivalent basis. However, the figures showing a full-time equivalent basis by using OECD's estimating method (including social sciences and humanities) also are indicated.

3. Germany and France: the years for which data are not available are indicated as a straight line.

4. OECD estimates the number of researchers for the United Kingdom in 1987 at 127,000.

Source: Same as in Figure 2-1-1.

Germany - OECD statistics for the data on 1970.

France - OECD statistics for the data before 1981.

(See Appendix 1, 8)

researchers are concentrated in government research institutions, universities and colleges (Figure 2-2-3).

The following sections show the characteristics of researchers in Japan by sector.

2.2.1.3.1. Companies

In the last 10 years from 1980 to 1990, the number of researchers in companies has increased 1.81 times (an average annual rate of increase of 6.1%) (Figure 2-2-4).

In industry, 300,000 of the researchers are in manufacturing (95.7%). Of all researchers within manufacturing, the electrical machinery industry tops the list at 119,000 researchers or 38.0% of the total. Next is the chemical industry with 52,000 researchers or 16.6%. These two industries account for approximately half of all company researchers.

By field of research, engineering ranks the highest at 61.8%. Next is the physical sciences at 26.2%, followed by health at 3.2%, and finally agricultural sciences at 2.8%. Within the engineering field, researchers are concentrated in electrical and telecommunications engineering, mechanical engineering, shipbuilding and aeronautical engineering. Within the physical sciences, chemistry has the majority. These three fields employ three-fourths of all company researchers (Figure 2-2-5).

Regarding the number of researchers per 10,000 employees, the average number throu-

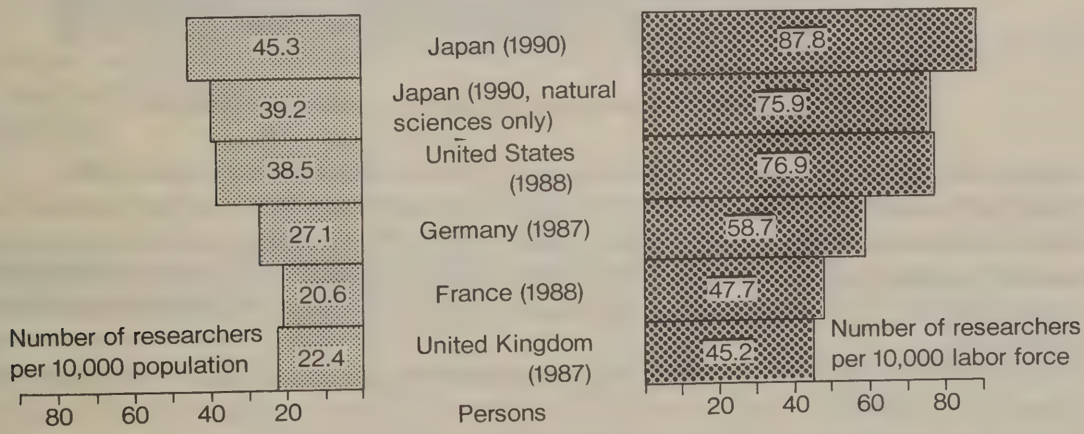


Figure 2-2-2. Researchers per 10,000 population and 10,000 labor force

Note: 1. The figures for all countries include social sciences and humanities. The statistics for Japan also show the data for researchers in natural sciences only.

2. Only the figures for Japan are not on a full-time equivalent basis. However, the figures on a full-time equivalent basis by using OECD's estimating method (including social sciences and humanities) are 37.0 researchers per 10,000 population and 71.7 researchers per 10,000 labor force.

Source: Numbers of researchers data: Same as in Figure 2-1-1.
United Kingdom - OECD statistics
Population and labor force data: Japan - "Data on the Current Population Estimates" and "Report on the Labor
Force Survey" compiled by the Statistics Bureau, Management and Coordination Agency
U.S. - Data from the Department of Commerce and the Department of Labor
Other countries - OECD statistics
(See Appendix 1)

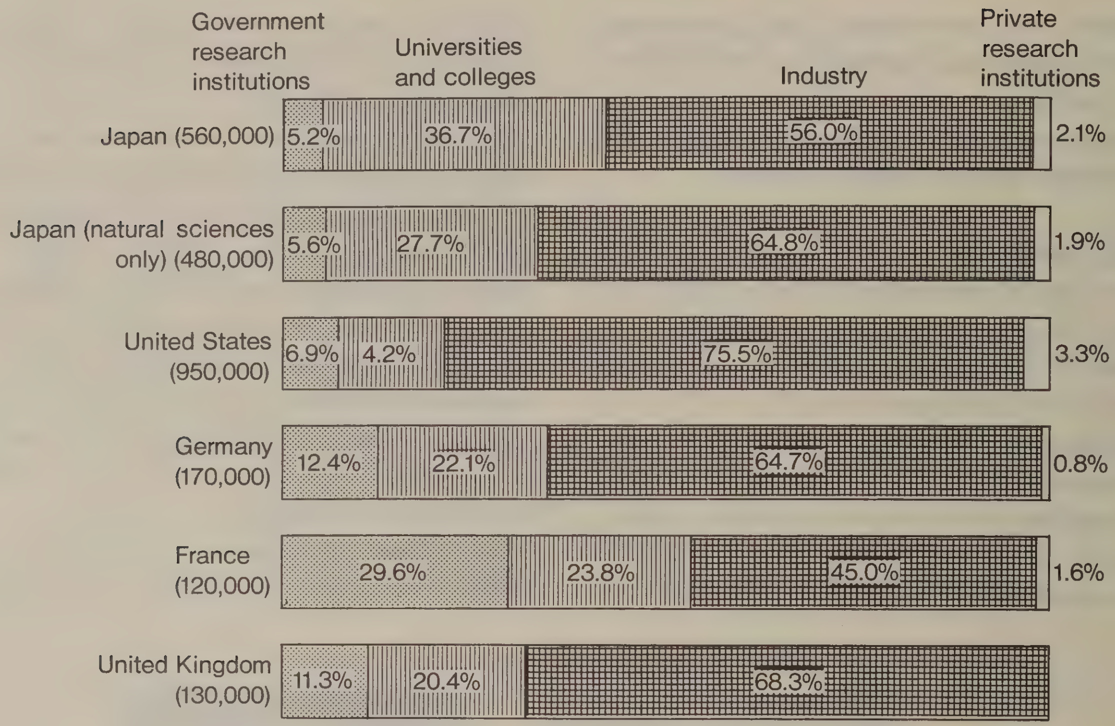


Figure 2-2-3. Share of researchers by sector in selected countries

Note: 1. Japan: 1990, United States: 1989, Germany: 1987, France: 1988, United Kingdom: 1987.
2. Only the figures for Japan are not on a full-time equivalent basis. However, the figures on a full-time equivalent basis by using OECD's estimating method (including social sciences and humanities) show that the shares of researchers by sector are 6.4% for government research institutions, 22.5% for universities and colleges, 68.6% for industry, and 2.5% for private research institutions.
3. The data for the United Kingdom are OECD estimates and do not include researchers in private research institutions.

Source: Japan, U.S. and Germany - Same as in Figure 2-1-1.
France and United Kingdom - OECD statistics
(See Appendix 8)

ghout all industry sectors is 476. The average number in the manufacturing sector is highest at 577. Within manufacturing, following sectors rank at the top.

- Electrical machinery: 978
- Chemicals products: 938
- Precision instruments: 831
  (Figure 2-2-6).

2.2.1.3.2. Research Institutions

For the last 10 years, researchers in research institutions have increased 27% (an average annual rate of increase of 2.4%). This is due to an increase in the number of private research institutions. Looking at the number of researchers by organization, the national

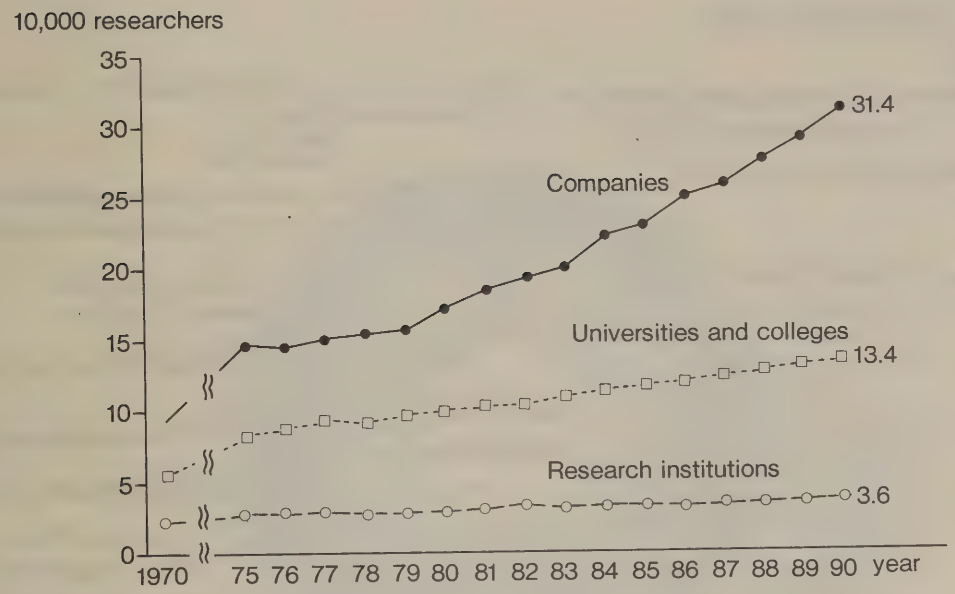


Figure 2-2-4. Trends in number of researchers by sector in Japan

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 8)

research institutions have 10,000 researchers or 28.1% of the total for research institutions, local government-owned research institutions have 14,000 researchers at 37.8%, private research institutions have 9,000 researchers at 25.5%, and public corporations have 3,000 researchers at 8.5% (Figure 2-2-7).

By field, researchers in engineering are most numerous at 36.9%, next is agricultural sciences at 33.9%, followed by the physical sciences at 20.7%, and finally health at 7.4% (Figure 2-2-8).

2.2.1.3.3. Universities and Colleges

The number of researchers at universities and colleges has increased 33.2% in the last 10 years (an average annual rate of increase of 2.9%). Looking at the number of researchers by type of institution in 1990, national universities and colleges have 73,000 researchers (54.8% of the total for universities and colleges), public universities and colleges have 9,000 researchers (7.1%), and private universities and colleges have 51,000 researchers (38.2%) (Figure 2-2-9).

By field, health ranks first at 59.0%, followed by engineering at 20.1%, physical sciences at 11.1%, and agricultural sciences at 5.9%. Researchers in universities and colleges are classified into faculty members, doctoral students, medical staff and others. Looking at the composition of researchers by type of institution, in national universities and colleges, doctoral students make up a large ratio of the researchers, public universities and colleges have a greater ratio of medical staff and others, and private universities and colleges have a greater ratio of faculty members and a smaller ratio of doctoral students (Figure 2-2-10).

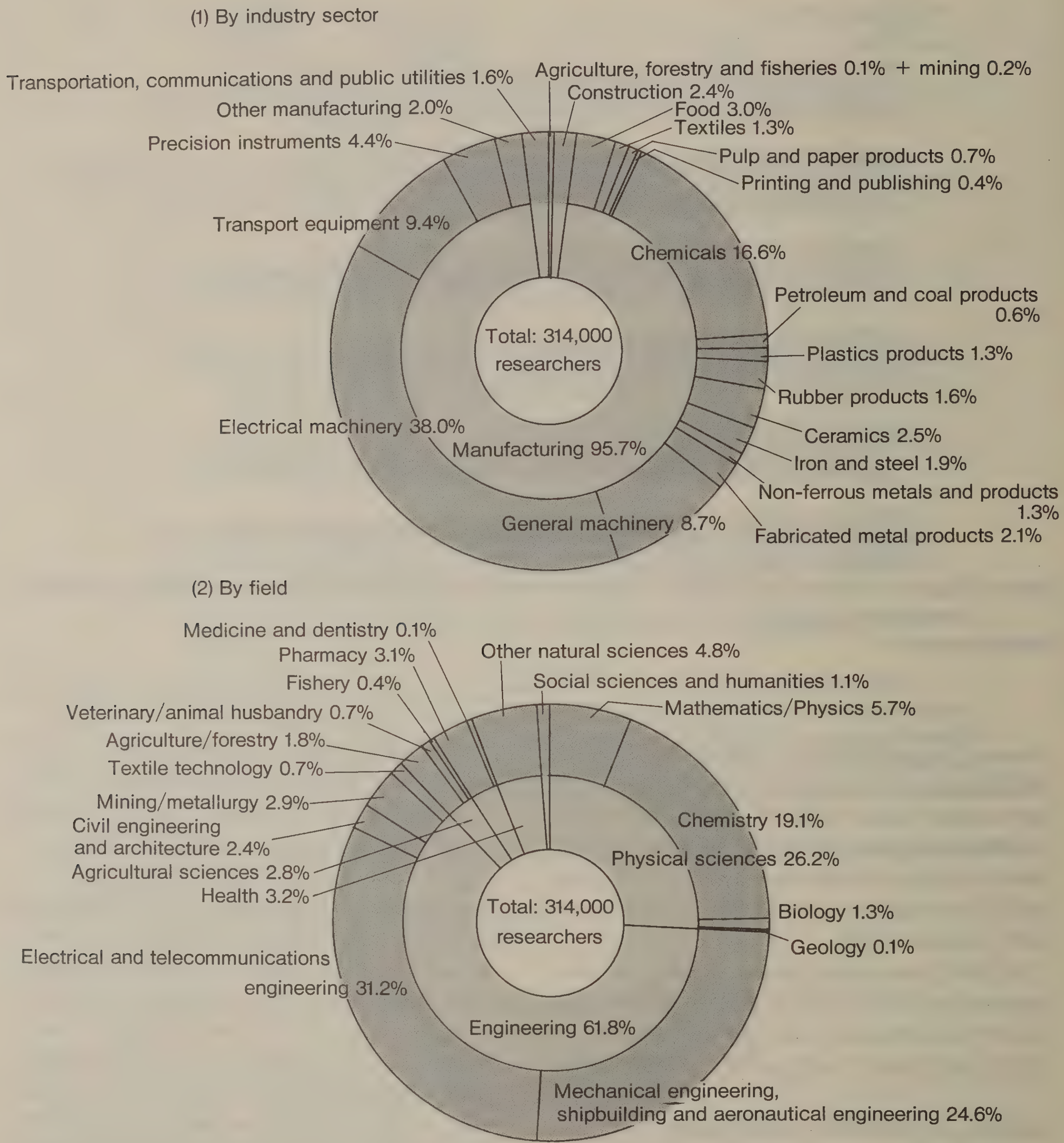


Figure 2-2-5. Number of company researchers by industry sector and by field of research

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 9)

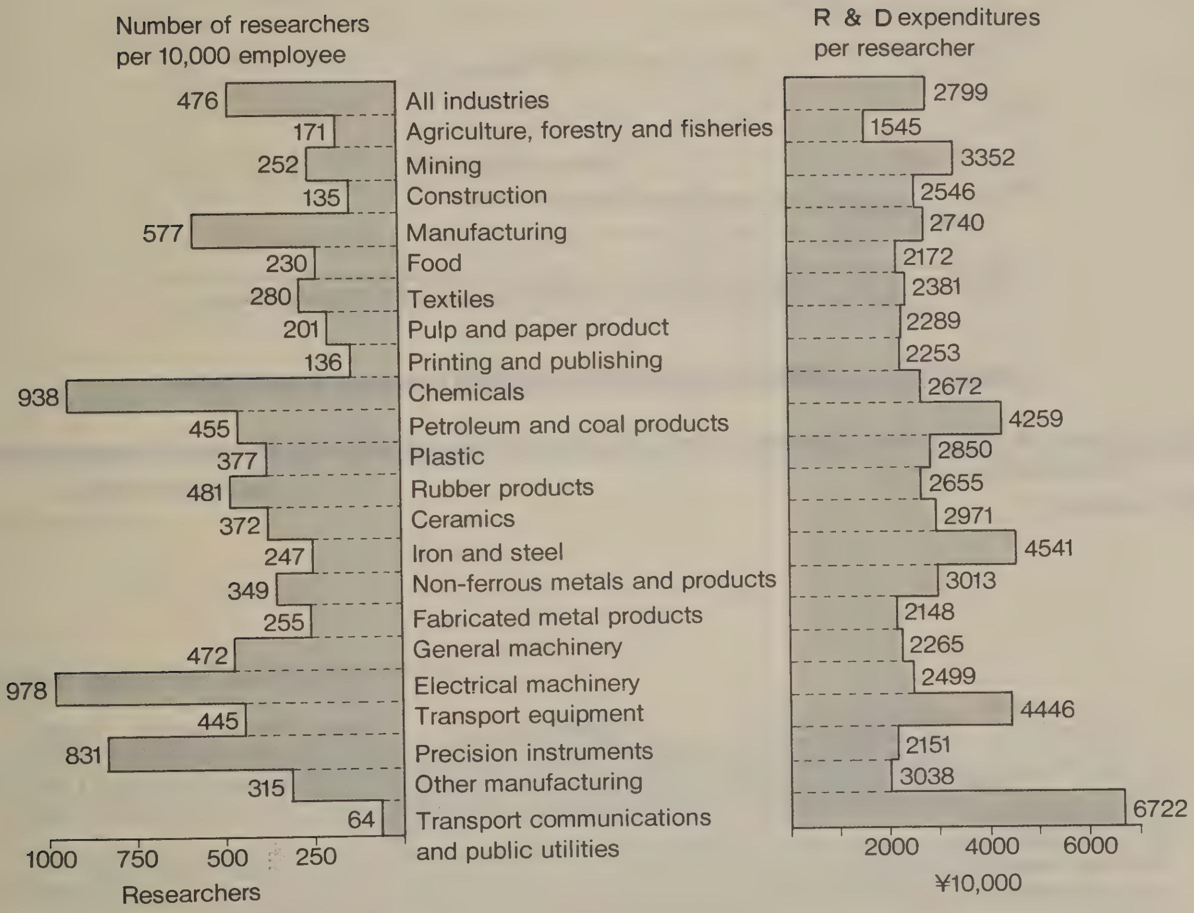


Figure 2-2-6. Number of researchers per 10,000 employees and R&D expenditures per researcher in companies

Note: 1. As for the R&D expenditures per researcher, the data for the number of researchers are as of April 1, 1989, and the data for research expenditures are as of FY1989.

2. Regarding researchers per 10,000 employees, the data for number of employees and number of researchers are as of April 1, 1990.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

(See Appendix 9)

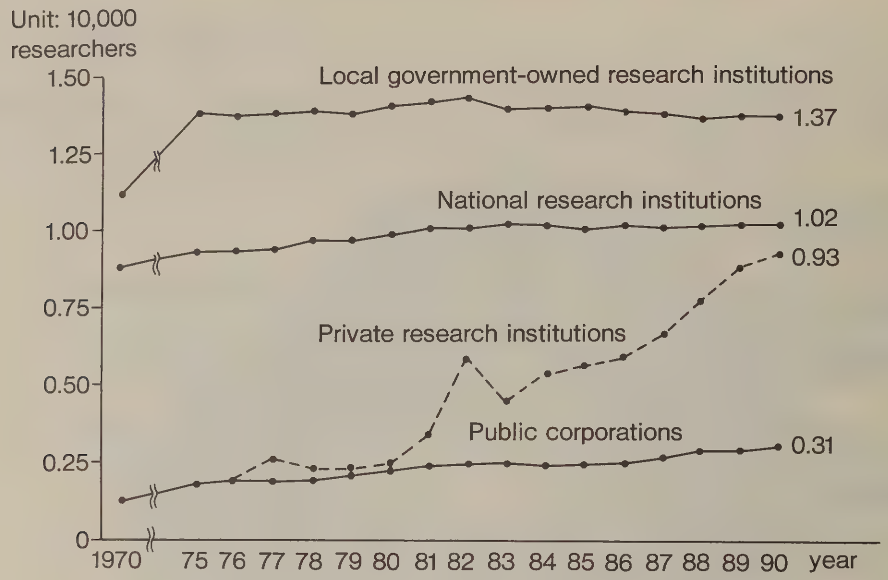


Figure 2-2-7. Trends in number of researchers in research institutions

Source: "Report on the Survey of Research and Development" by the Statistics Burȩau, Management and Coordination Agency.
(See Appendix 8)

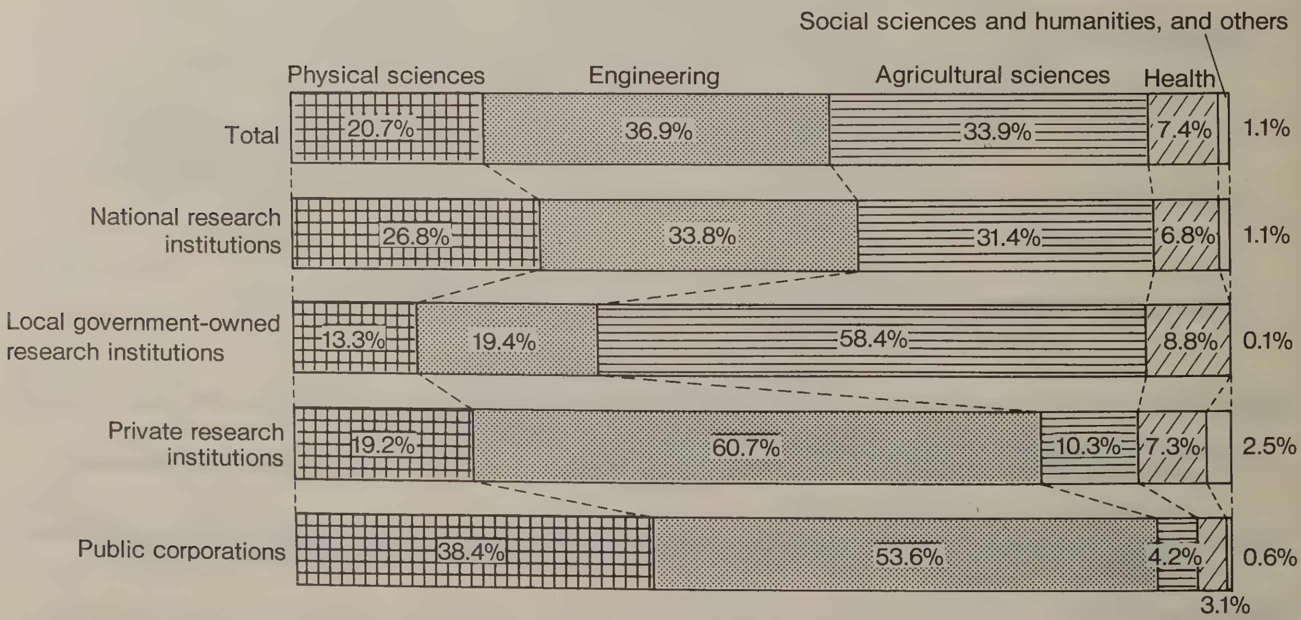


Figure 2-2-8. Share of researchers in research institutions by organization and field (1990)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

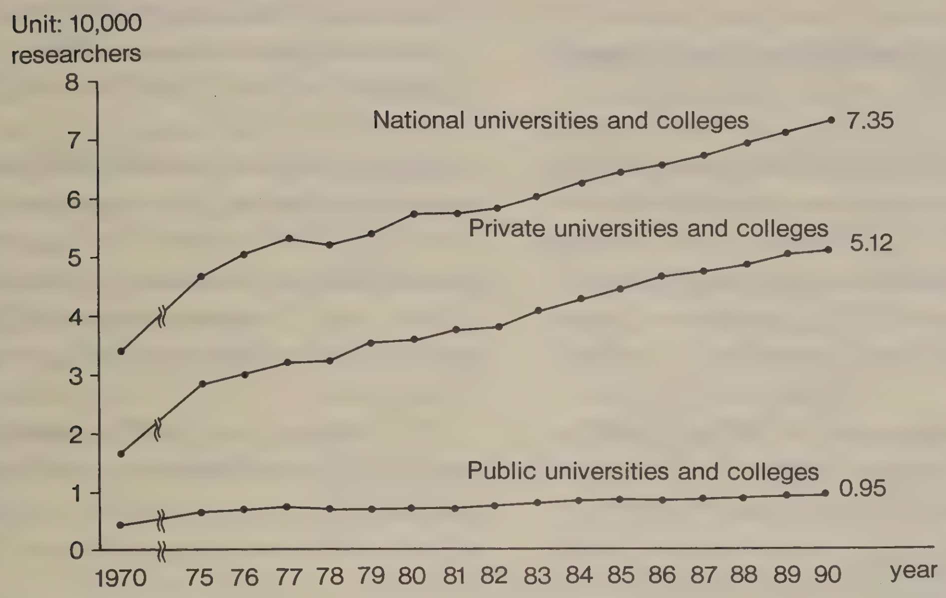


Figure 2-2-9. Trends in number of researchers in universities and colleges

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 8)

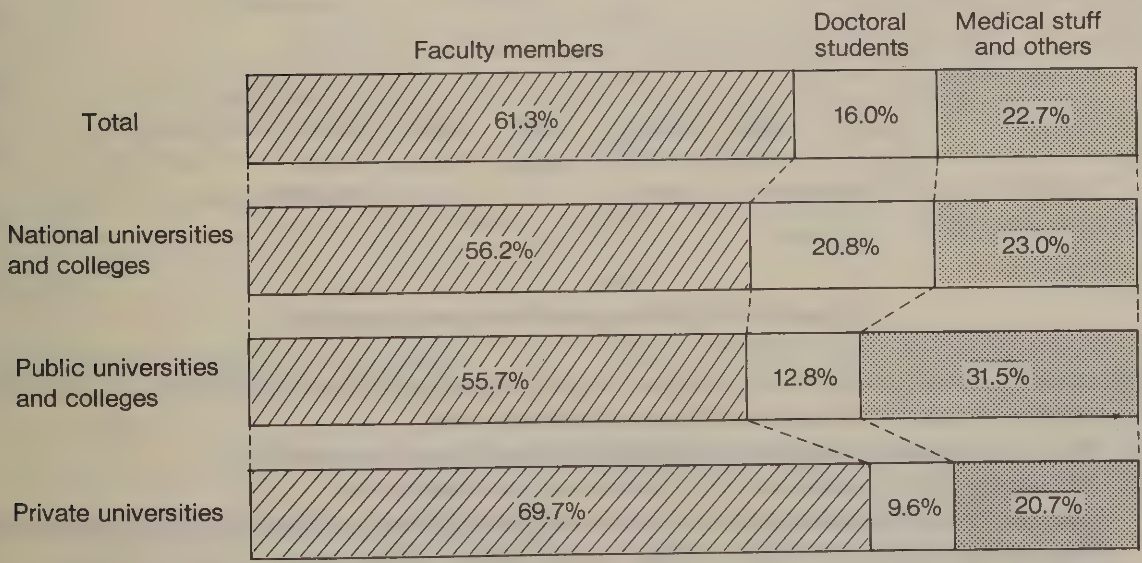


Figure 2-2-10. Composition of researchers in universities and colleges (1990)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

2.2.2. R&D Expenditures per Researcher

Though it is difficult to compare R&D expenditures per researcher due to differences in research systems (e.g., differences in the number of research support personnel), the following is a rough estimate of R&D expenditures (including labor costs) per researcher in selected countries.

- Japan: 22 million yen (FY1989) (24 million yen: natural sciences only)
- United States: 30 million yen (FY1988)
- Germany: 30 million yen (FY1987)
- France: 32 million yen (FY1988)
- United Kingdom: 27 million yen (FY1987) (Figure 2-2-11).

In Japan, R&D expenditures per researcher are generally increasing in every sector (in current yen). In FY1989, research institutions have the greatest R&D expenditure per researcher (38.19 million yen). Companies spent 27.99 million yen, and universities and colleges spent 9.96 million yen.

The changes in R&D expenditures per researcher in real terms are as follows:(Figure 2-2-12)

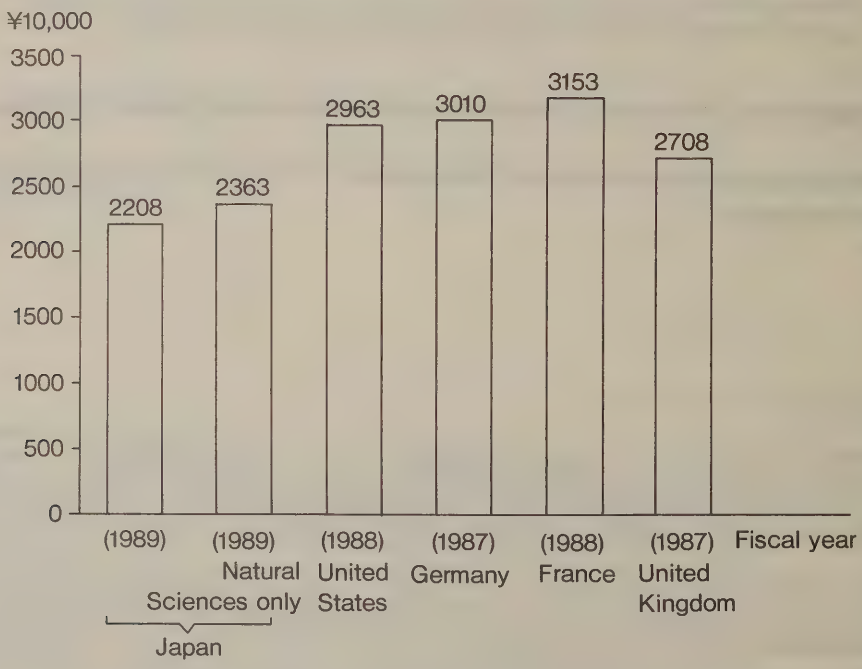


Figure 2-2-11. R&D expenditures per researcher

Note: 1. For comparison, figures for all countries include social sciences and humanities. The figure for Japan shows also the amount with natural sciences only.
2. R&D expenditures were converted using OECD's purchase power parity.
3. Only the figures for Japan are not on a full-time equivalent basis. However, the figure converted on a full-time equivalent basis by using OECD's estimating method (1988, including social sciences and humanities) is 23.9 million yen.
4. The number of researchers in the United Kingdom is an OECD estimate.

Source: Same as in Figure 2-1-1.
United Kingdom - Cabinet Office "Annual Review of Government funded R&D" for R&D expenditures. OECD statistics for the number of researchers.

(See Appendix 1)

- In the early 1970s, there was a decrease due to a rise in prices caused by the oil crisis.
- In the late 1970s, there was an increase in expenditures per researcher.
- In FY1989, the R&D expenditures per researcher reached 22.55 million yen (in constant FY1985 yen).

The following shows R&D expenditures per researcher by industry sector.

- Transport/communications/public utilities: 67.22 million yen
- Mining: 33.52 million yen
- Manufacturing: 27.40 million yen

In manufacturing the following sectors have high R&D expenditures per researcher. (Figure 2-2-6).

- Iron and steel: 45.41 million yen
- Transport equipment: 44.46 million yen
- Petroleum and coal products: 42.59 million yen

In research institutions, R&D expenditures per researcher by organization are as follows:

- Public corporations: 143.46 million yen
- Private research institutions: 49.99 million yen
- National research institutions: 26.71 million yen
- Local government-owned research institutions: 16.50 million yen

R&D expenditures per researcher in universities and colleges are on average 9.96 million yen. However, taking into consideration only faculty members who are actually doing research, the figure is 16.26 million in all universities and colleges. This figure varies according to type of university and college as follows.

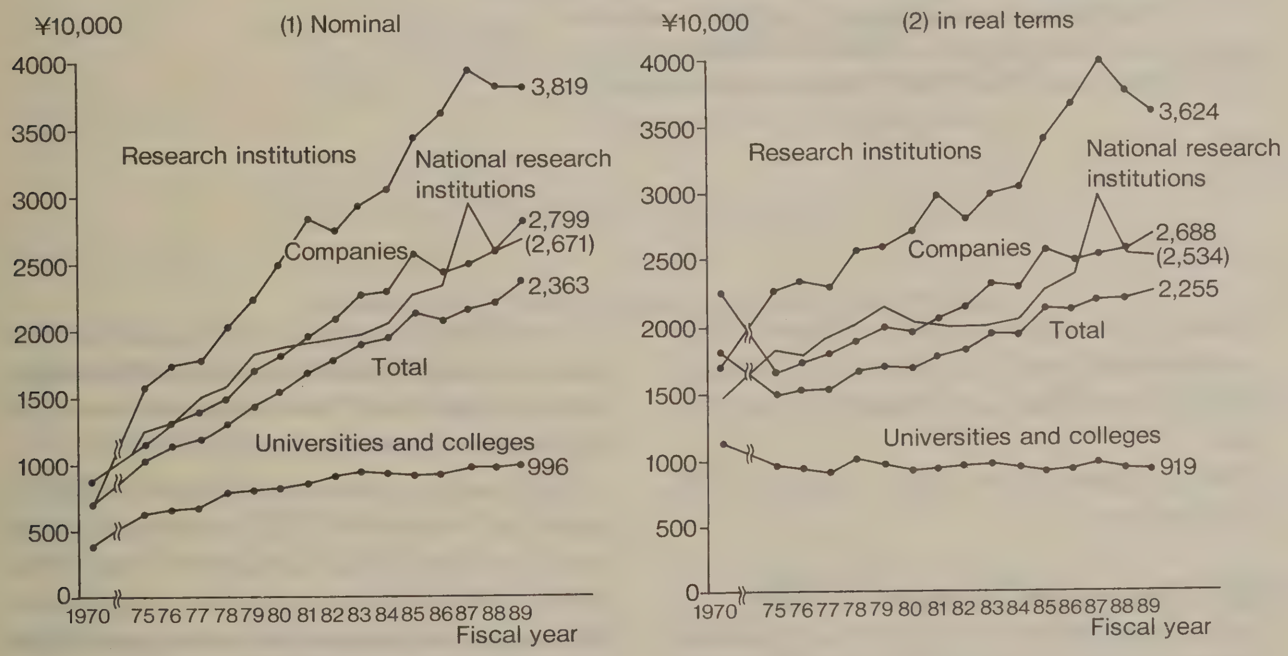


Figure 2-2-12. Trends in R&D expenditures per researcher

Note: 1. Each figure equals R&D expenditures of the relevant fiscal year divided by the number of researchers (as of April 1)
2. Figures in real terms are converted in constant 1985 yen.
3. The data for national research institutions are indicated in a thin line.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

(See Appendix 5, 8, 15)

Table 2-2-13. Personnel engaged in R&D in selected countries

Country (Year)	Total Number of personnel engaged in R&D	Number which are Non-researchers	Non-researcher per researcher
Japan (1990)	863,382	303,106	0.54
Japan natural sciences only (1990)	769,696	285,350	0.59
Germany (1987)	419,205	253,591	1.53
France (1988)	283,099	167,936	1.46
United Kingdom (1987)	282,273	154,860	1.22

Note: 1. For comparison, figures for all countries include social sciences and humanities. The figure for Japan shows also the number with natural sciences only.
2. The data for United Kingdom are OECD estimates.
Source: Japan and Germany - Same as in Figure 2-1-1.
France and the United Kingdom: OECD statistics

- National universities and colleges: 17.27 million yen
- Public universities and colleges: 14.25 million yen
- Private universities and colleges: 15.37 million yen

2.2.3. Personnel Engaged in R&D

Although the definition of personnel engaged in R&D is not same in each country, numbers of personnel engaged in R&D (including researchers) are as follows:

- Japan: 863,000 (770,0000: natural sciences only)
- Germany: 419,000
- France: 283,000
- United Kingdom: 282,000

It is difficult to compare these numbers at face value. Compared with European countries, Japan has a comparatively low number of personnel supporting researchers (Table 2-2-13).

The number of personnel engaged in R&D in Japan has increased 47.7% (an average annual rate of increase: 4.0%) during the 10 years from 1980 to 1990. This increase was mostly due to the increase in numbers of researchers (Figure 2-2-14). The percentage of researchers of all personnel engaged in R&D has increased from 58.1% in 1980 to 62.9% in 1990. On the other hand, the share of assistant research workers decreased from 14.2% to 13.4%. The percentage of technicians decreased from 16.5% to 13.4%. Clerical and other supporting personnel have decreased from 11.3% to 10.3%. As a result, the number of assistant research workers and

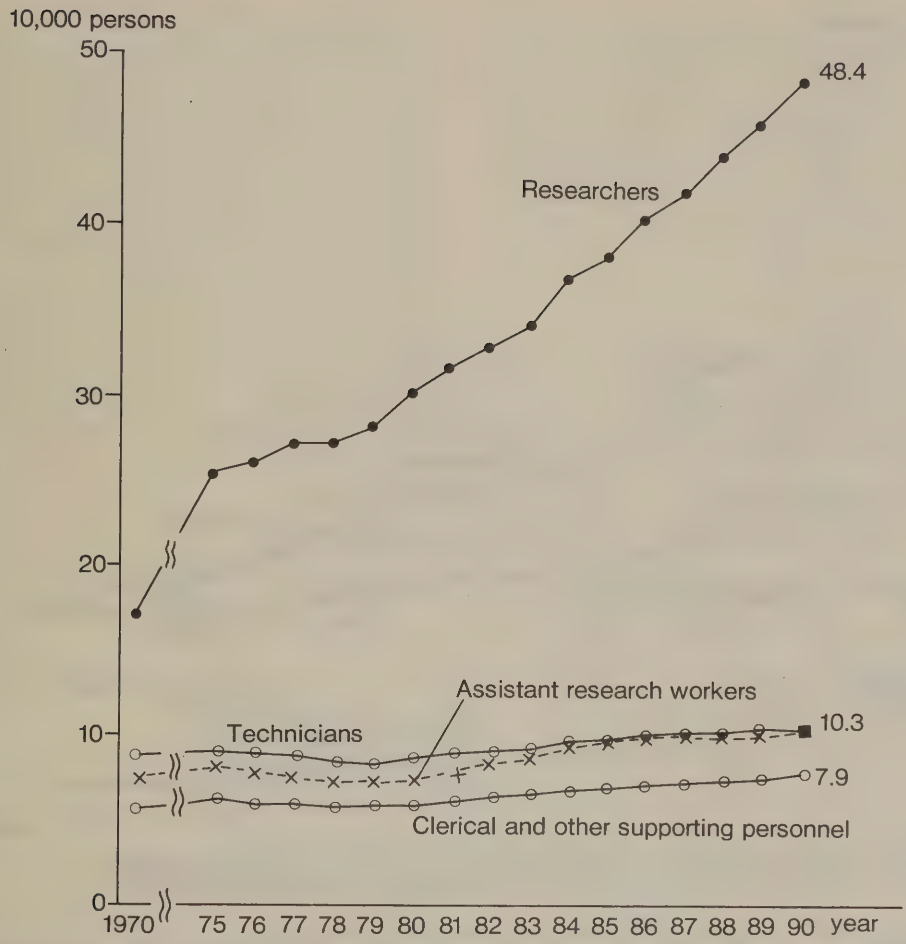


Figure 2-2-14. Trends in persons engaged in R&D in Japan

Source: "Report on the Survey of Research and Development", compiled by the Statistics Bureau, Management and Coordination Agency
(See Appendix 7)

technicians per researcher has been decreasing and was 0.43 in 1990 (Figure 2-2-15).

A breakdown of the number of personnel engaged in R&D by sector shows that companies have a larger ratio of support personnel than other sectors and that universities and colleges have a larger ratio of researchers (Figure 2-2-16).

In companies the number of personnel engaged in R&D is 528,000. Researchers account for 314,000 (59.4% of the total for companies), assistant research workers 86,000 (16.4%), technicians 81,000 (15.4%), and clerical and other supporting personnel 47,000 (8.8%). Looking at the breakdown of personnel engaged in R&D by industry, the researcher ratio is high in transport/communications/public utilities (68.2%) and construction (67.1%). In manufacturing, the researcher ratio is high in printing and publishing (69.4%) and general machinery (68.1%) while the researcher ratio is relatively

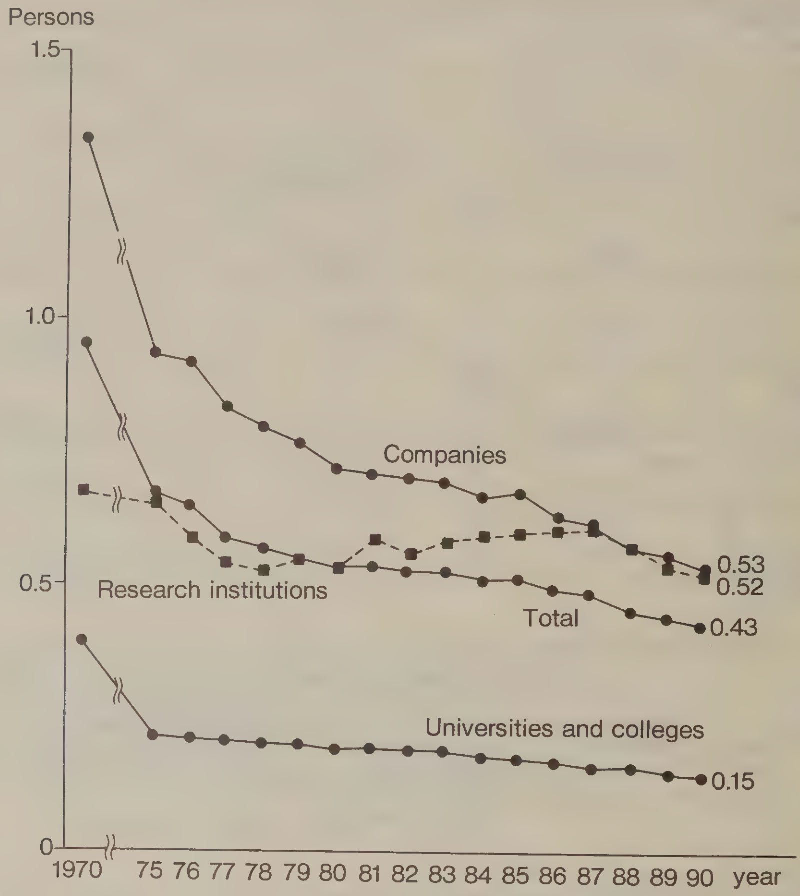


Figure 2-2-15. Trends in number of assistant research workers and technicians per researcher in Japan

Source: "Report on the Survey of Research and Development" compiled by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 7)

low in transport equipment (43.0%) and iron and steel (46.5%).

In research institutions the number of personnel engaged in R&D is 73,000. Researchers account for 36,000 (49.9% of the total for research institutions), assistant research workers 8,000 (11.3%), technicians 11,000 (14.6%), and clerical and other supporting personnel 18,000 (24.3%). The data by types of research institutions indicate that national and local government-owned research institutions have a larger ratio of researchers and private research institutions and public corporations have a larger ratio of assistant research workers.

Personnel engaged in R&D at universities and colleges total 169,000. Researchers account for 134,000 (79.6%of the total for universities and colleges), assistant research workers 8,000 (5.0%), technicians 11,000 (6.7%), and clerical and other supporting personnel 15,000 (8.7%).

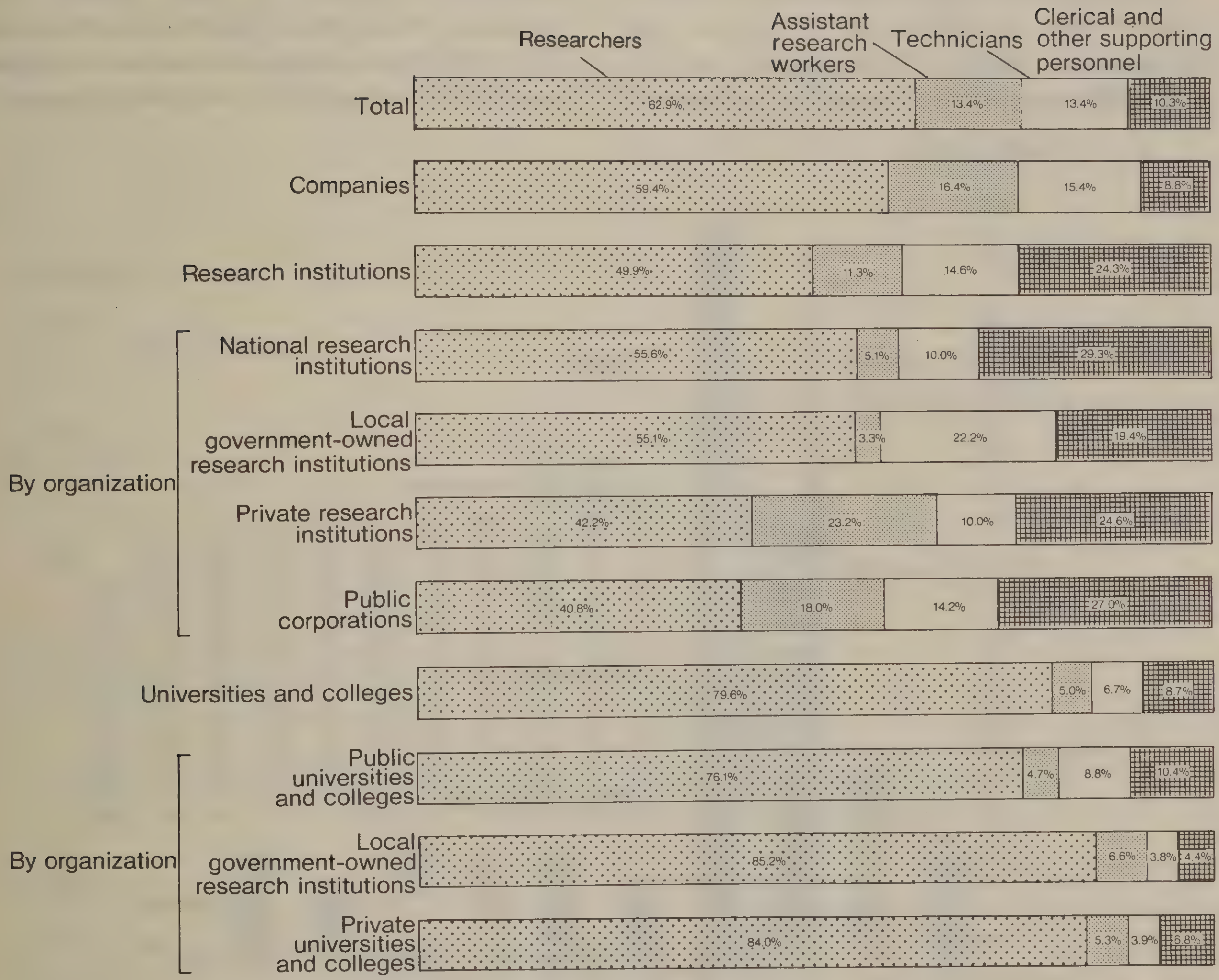


Figure 2-2-16. Composition of personnel engaged in R&D by sector in Japan (1990)

Source: "Report on the Survey of Research and Development" compiled by the Statistics Bureau, Management and Coordination Agency.

2.2.4. Overall Degree Trends

Due to the decreasing percentages of youth in the populations of major countries, great efforts are being made to nurture and secure researchers. Data on numbers of master's and doctoral degrees, therefore, are important.

The number of degrees differ from country to country due to differences in culture and educational systems. Social factors such as industrial structure and number of students can affect the number of awarded degrees. Thus, it is difficult to compare the data at face value. It is useful, however, to compare trends, and this section describes the degree trends in natural sciences and engineering in selected countries.

The United States awards the largest number of degrees, about 4.4 times as many as does Japan. Compared to a decade ago, the ratio of engineering degrees to total degrees has increased while that of physical sciences has decreased. Japan is second in number of degrees awarded following the U.S. and has a higher ratio

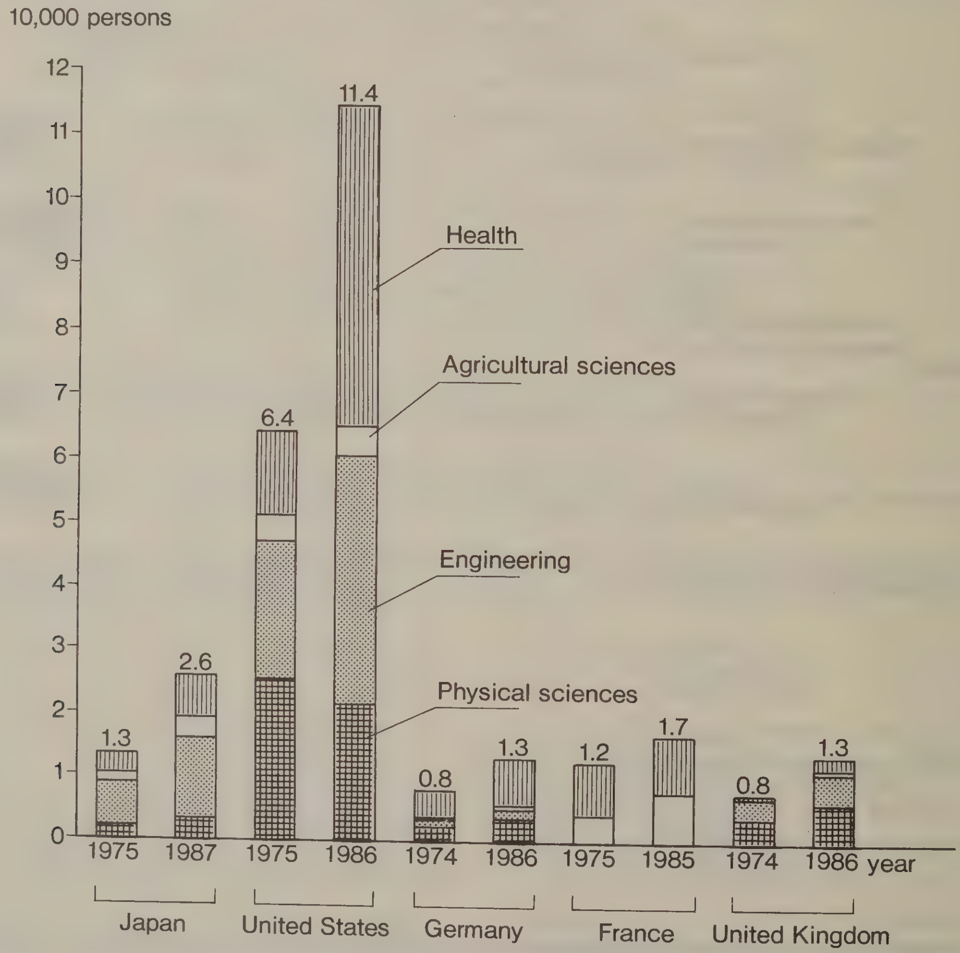


Figure 2-2-17. Number of awarded degrees in selected countries

Note: 1. Totals include master's and doctoral degrees. (Germany: only doctorates)
2. U.S. health degrees in 1986 include 29,000 persons with first-professional degrees which in 1975 corresponded to bachelor's degree.
3. France does not distinguish between physical sciences, engineering, and agricultural sciences.

Source: "International Comparison of Education Indexes", compiled by the Ministry of Education.

in engineering. Germany, France, and the United Kingdom have about the same number. Germany and France have a higher ratio of degrees awarded in health, the United Kingdom has a higher ratio in physical sciences (Figure 2-2-17).

In Japan the number of awarded degrees has increased in recent years. In FY1983, 13,182 master's degrees and 6,973 doctorates were awarded. In FY1988, 18,456 master's degrees (an increase of 40.0%) and 9,133 doctorates (an increase of 31.0%) were awarded. The largest increases have been in the ratios of master's degrees in engineering and doctorates in health (Figure 2-2-18).

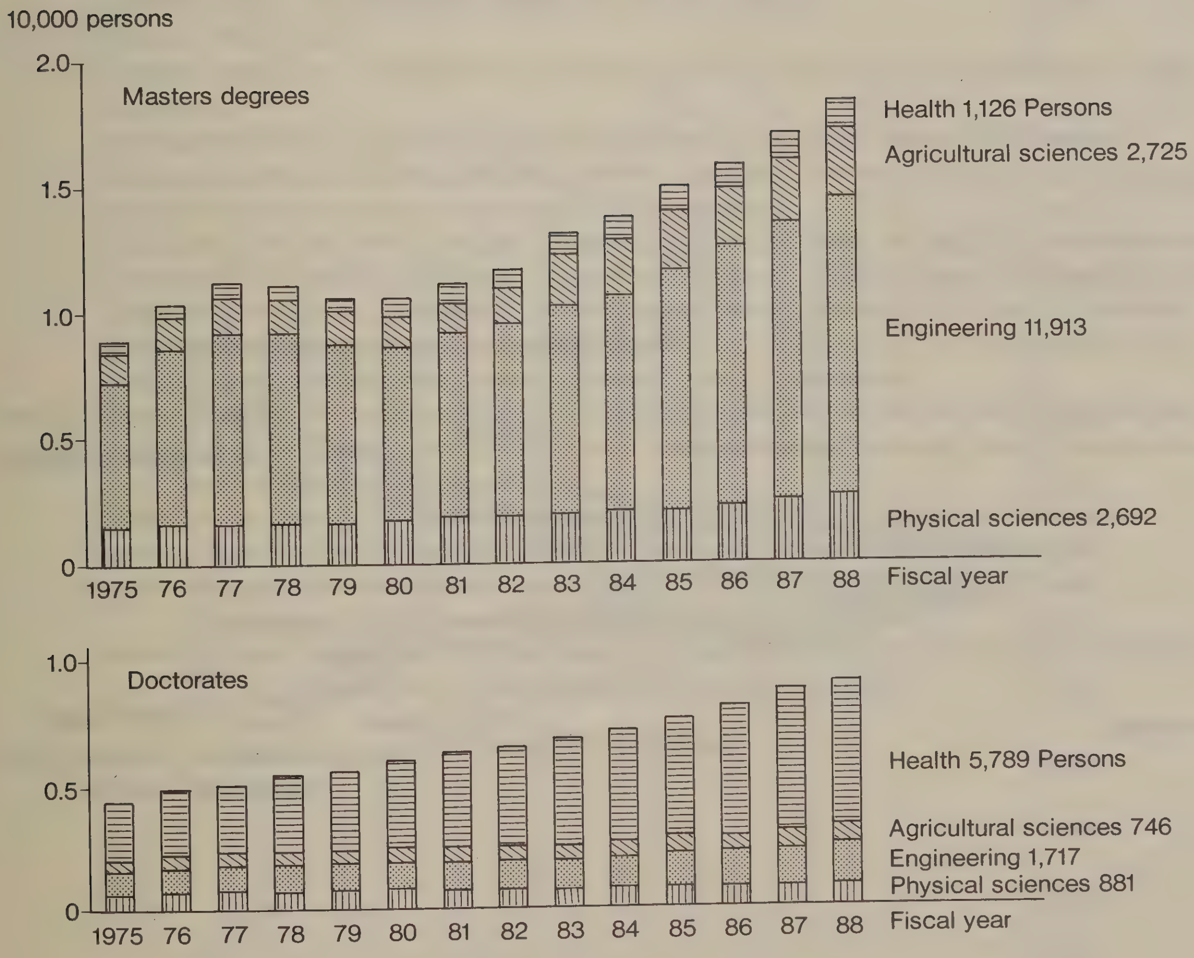


Figure 2-2-18. Degree Trends in Japan

Note: The figures are awarded degrees in FY1988.
Source: "Summary of Education Statistics" compiled by the Ministry of Education.

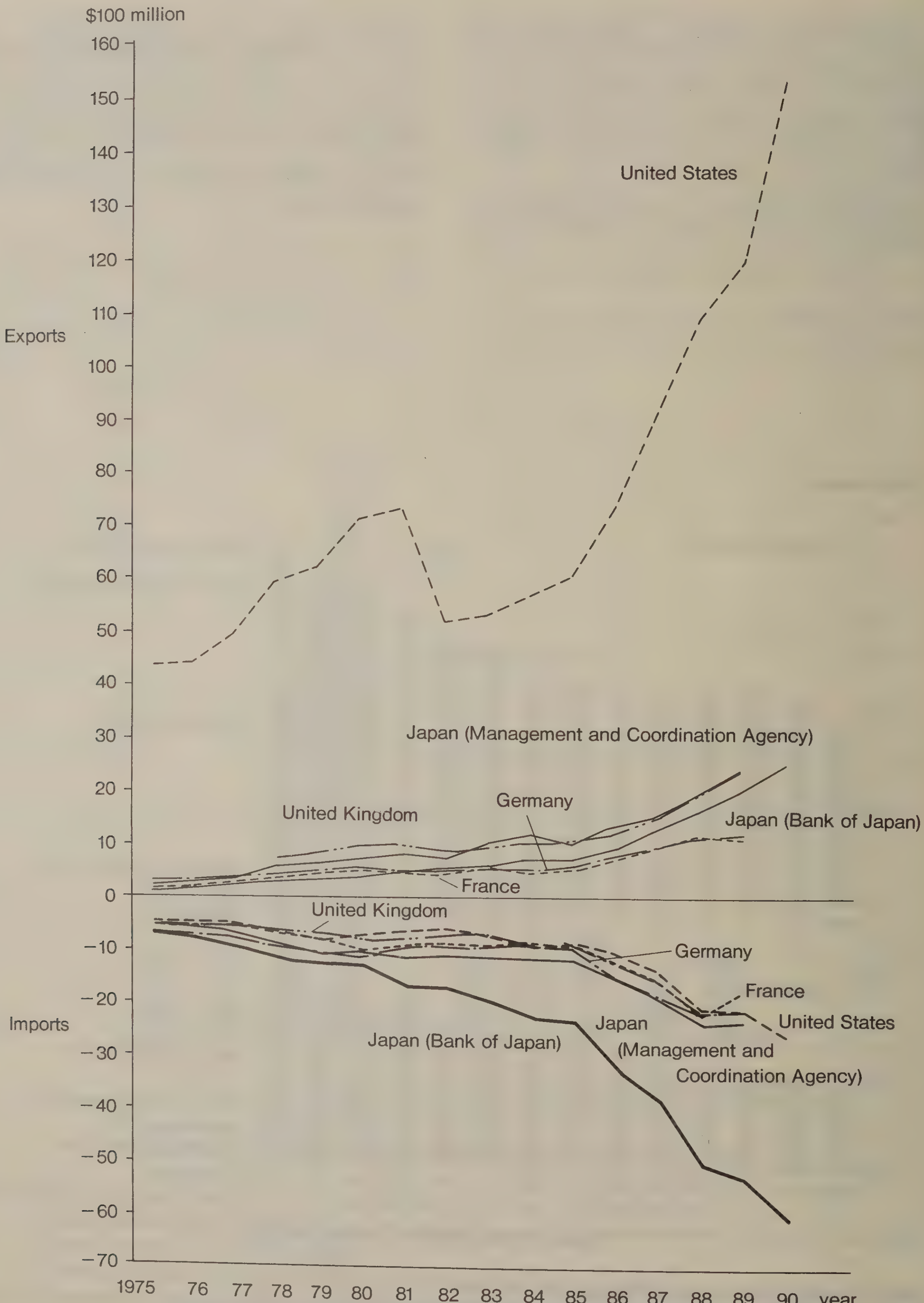


Figure 2-3-1. Trends in technology trade of selected countries

(Fig. 2-3-1)

Note: 1. The amounts are converted into dollars, according to IMF statistics.
2. Bank of Japan refers to the "Balance of Payments Monthly", compiled by the Bank of Japan. Management and Coordination Agency refers to the "Report on the Survey of Research and Development", compiled by the Statistics Bureau, the Management and Coordination Agency.
3. The figures are totals for the calendar year; the fiscal year is used only for the figures of Japan Management and Coordination Agency.
4. The United States changed the classification of statistics in 1982.
5. The United Kingdom changed its method of gathering data in 1987. Thus, new data cannot be compared with that prior to 1986.
6. The major reasons for differences between the figures provided by the Bank of Japan and those provided by the Management and Coordination Agency are as follows.

A. Method of data collection:

Bank of Japan: Out of foreign exchange, only remittances regarding receipts and payments of patents royalties are totalled.

Management and Coordination Agency: Any technology related payments and receipts (patents, know- how,technical assistance, etc.) are totalled.

B. Scope of the Survey:

Bank of Japan: Any corporation and institution that deals with remittances through foreign exchange.

Management and Coordination Agency: Excludes wholesalers, restaurants, finance companies, insurance companies, real estate companies, service oriented companies (except broadcasting) and research-centered public corporations.

Because of "A", technology export figures of the Bank of Japan, which do not include receipts for exported technology embodied in plant exports, are less than those of the Management and Coordination Agency. Because of "B", technology import, figures by the Management and Coordination Agency are less than those by the Bank of Japan, because the former do not include tertiary industry and research-oriented public corporations.

Source: Japan - "Balance of Payments Monthly", compiled by the Bank of Japan, and "Report on the Survey of Research and Development" compile by the Statistics Bureau, Management and Coordination Agency

United States - "Survey of Current Business" compiled by the Department of Commerce

German - "Monatsberichte der deutschen Bundesbank" by the Deutsche Bundesbank

France - Ministers de l'Economie, des Finances et du Budget "Statistiques & Etudes Financieres", "La Balance des Paiements de la France"

United Kingdom - Department of Trade and Industry "Business Monitor,Overseas transactions" (1970-1984), Central Statistical Office data (1985-)

(See Appendix 11, 12, 13)

2.3 Technology Trade and Patents

The data on technology trade balances and number of patents applied for and granted are significant indicators showing a nation's level and strength of R&D activities in science and technology. This chapter describes these trends for in Japan and selected countries.

2.3.1. Trade in Technology

Patents, utility models, and technical know-how are results of R&D efforts in science and technology. They are traded internationally, for example in the form of transfer of rights, approval of utilization, and others. These transactions are what are known as technology trade.

2.3.1.1. Trends in the Technology Trade of Selected Countries

The technology exports and imports of major counties are expanding. This is due to active product development and the globalization of industrial production and R&D activities. This trend has been apparent since 1985 (Figure 2-3-1).

The technology exports of the United States are significantly larger, at 15.3 billion dollars (1990, 2.21 trillion yen), than the following countries:

- Japan: 2.5 billion dollars (1990, 360 billion

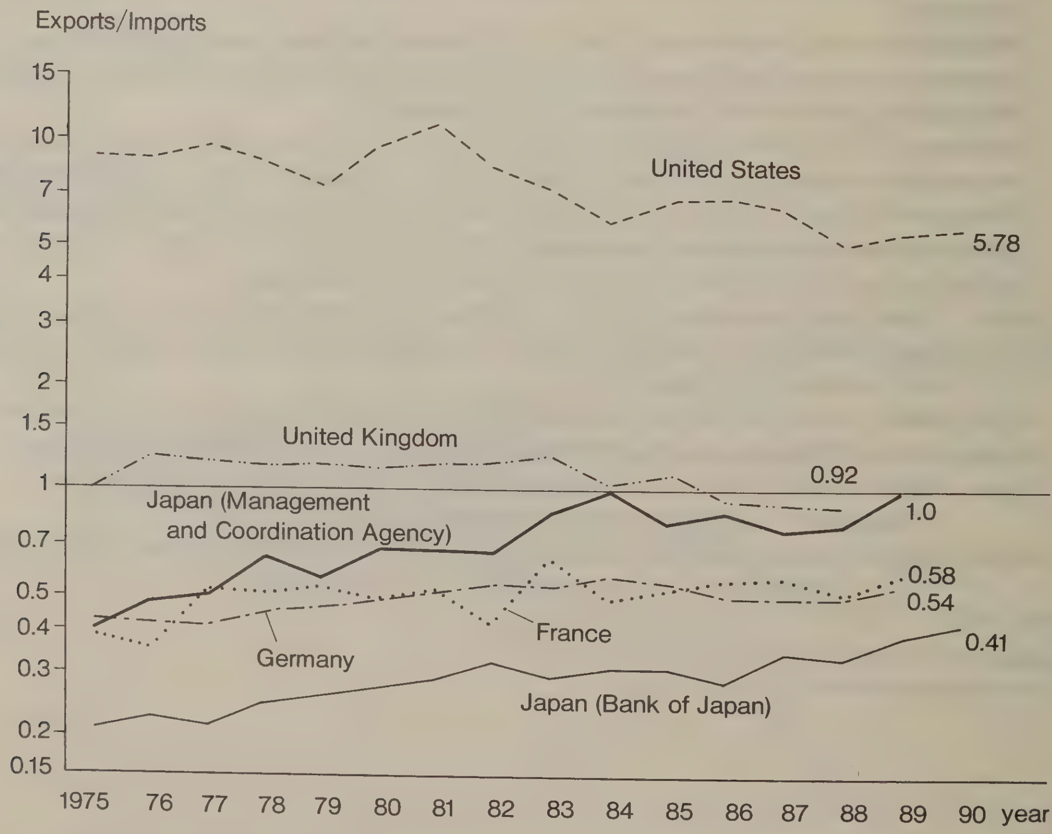


Figure 2-3-2. Trends in technology trade balance of selected countries

Source: Same as in Figure 2-3-1.
(See Appendix 11, 12, 13)

yen) (Bank of Japan statistics)
- Japan: 2.4 billion dollars (FY1989,330 billion yen) (Management and Coordination Agency statistics)
- United Kingdom: 1.9 billion dollars (1988, 240 billion yen)
- Germany: 1.2 billion dollars (1989, 160 billion yen)
- France: 1.0 billion dollars (1989, 140 billion yen)

In contrast, technology imports amount to the following:
- Japan: 6.0 billion dollars (1990, 870 billion yen) (Bank of Japan statistics)
- Japan: 2.4 billion dollars (FY1989, 330 billion yen) (Management and Coordination Agency statistics).
- United States: 2.6 billion dollars (380 billion yen)
- Germany: 2.2 billion dollars (300 billion yen)
- United Kingdom: 2.0 billion dollars (260 billion yen)
- France: 1.8 billion dollars (250 billion yen)

Only the U.S. has a significant surplus in its technology trade balance. In 1990, the U.S. technology trade surplus was 12.6 billion dollars (1.83 trillion yen) and its ratio (export/import) was 5.78. The United Kingdom has a small deficit, its ratio is 0.92, although it is not possible to compare these data with former figures due to the changes in the method of gathering data in 1987. France and Germany have experienced little change in recent years, with ratios of 0.58 and 0.54 respectively.

The U.S. has a surplus in any bilateral relations with other major countries. Between Germany and France it is almost balanced.

In Japan the technology trade balance has been generally improving since 1970s. According to statistics of the Management and Coordination Agency, Japanese technology trade balance was 1.00 in FY1989. Statistics of the Bank of Japan also shows the general improvement, but also show that the deficit has been increasing in recent years; in 1990 the deficit was 3.6 billion dollars (520 billion yen) (Figure 2-3-2).

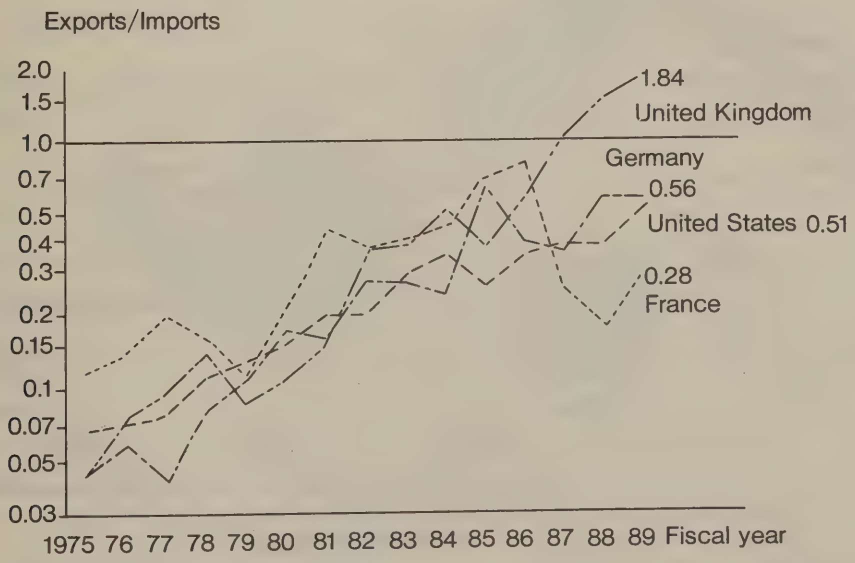


Figure 2-3-3. Trends in technology trade balance of Japan with other selected countries

Source: "Report on the Survey of Research and Development", compiled by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 13)

2.3.1.2. Japan's Trade in Technology with Other Countries and Regions

According to statistics of the Management and Coordination Agency, Japan's technology trade balance with major countries is improving. This indicates that the level of domestic technology is progressing. Japan has a trade surplus in technology with the United Kingdom (Figure 2-3-3).

A look at the situation in FY1989 by country and region shows that technology exports to Asia (excluding west Asia) had the largest figure with 128.9 billion yen. The breakdown by country is as follows:

- Korea: 38.5 billion yen
- China: 24.4 billion yen (including Taiwan, 16.3 billion yen)
- Thailand: 17.6 billion yen
- Singapore: 16.1 billion yen

Japan's exports to Thailand have rapidly increased in recent years. The United States stands as the largest importer of Japanese technology at 107.7 billion yen. There was large increase of 51% over the previous year. Regarding technology imports into Japan, North America and Europe play a big role, which shows that Japanese corporations are seeking technology mainly in the United States and in European countries. Above all, technology imports from the United States in FY1988 were 209.5 billion yen (a 6.4% increase over the previous year), 63% of Japan's total imports. After the United States, the following countries are significant (Figure 2-3-4).

- France: 25.5 billion yen
- Germany: 24.3 billion yen
- Netherlands: 21.1 billion yen
- Switzerland: 19.0 billion yen

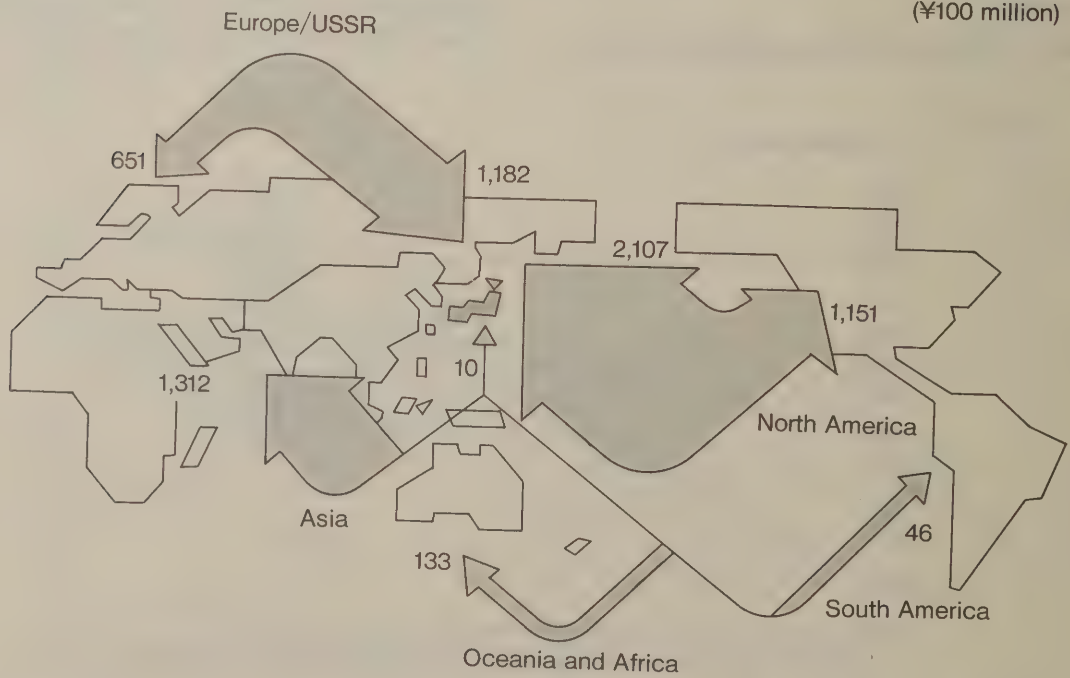


Figure 2-3-4. Trade in technology by region (FY1989)

Source: "Report on the survey of Research and Development" compiled by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 13, 14)

2.3.1.3. Trends of Japan's Trade in Technology

As described earlier, according to the statistics of the Bank of Japan for 1990 Japan's technology exports were 358.9 billion yen (a 23.0% increase over the previous year: dollar based comparison), and imports were 874.4 billion yen (a 13.4% increase). These statistics showed the technology export/import ratio changed from 0.38 in the previous year to 0.41 in 1990. According to the statistics of the Management and Coordination Agency, technology exports were 329.3 billion yen (a 24.2% increase over the previous year), and imports were 329.9 billion yen (a 1.8% decrease). As a result, the technology export to import ratio changed from 0.79 in the previous year to 1.00.

Technology trade data compiled by the Management and Coordination Agency since FY1972 indicates that technology trade from new contracts resulted in annual surpluses since FY1972 except in FY1987 and 1988. In FY1989 the trade again recorded a surplus with exports at 66.6 billion yen and imports at 48.4 billion yen. (Figure 2-3-5). The following are FY1989 statistics of technology trade exports by industry sector according to statistics of the Management and Coordination Agency.

- Transport equipment: 87.1 billion yen
- Electrical machinery: 86.7 billion yen
- Chemicals: 53.6 billion yen
- Iron and steel: 21.6 billion yen
- General machinery: 13.2 billion yen

The following are FY1989 statistics of technology trade imports by industry sector (Figure 2-3-6).

- Electrical machinery: 120.6 billion yen
- Chemicals: 56.9 billion yen
- Transport equipment: 54.9 billion
- General machinery: 33.0 billion yen

The amount of receipts is higher than that of payments in the construction and the iron and steel industries. This surplus has continued since FY1975 in construction and since FY1974 in the iron and steel industry. The electrical machinery and transport equipment industries, both of

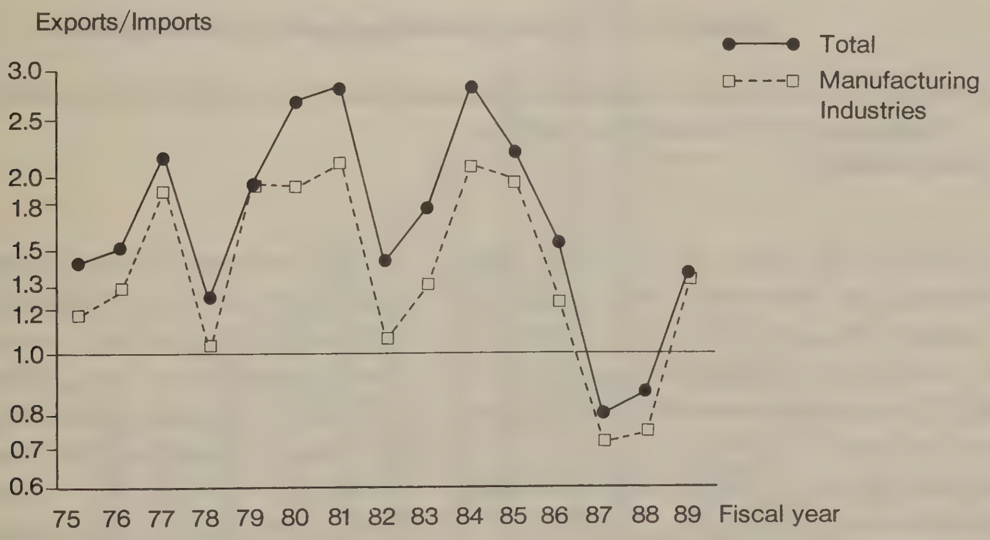


Figure 2-3-5. Trends in technology trade balance caused by new contracts

Note: "Technology trade in new contracts" refers to trade caused by newly made contracts in an applicable year.
Source: "Report on the Survey of Research and Development", compiled by the Statistics Bureau, Management and Coordination Agency.

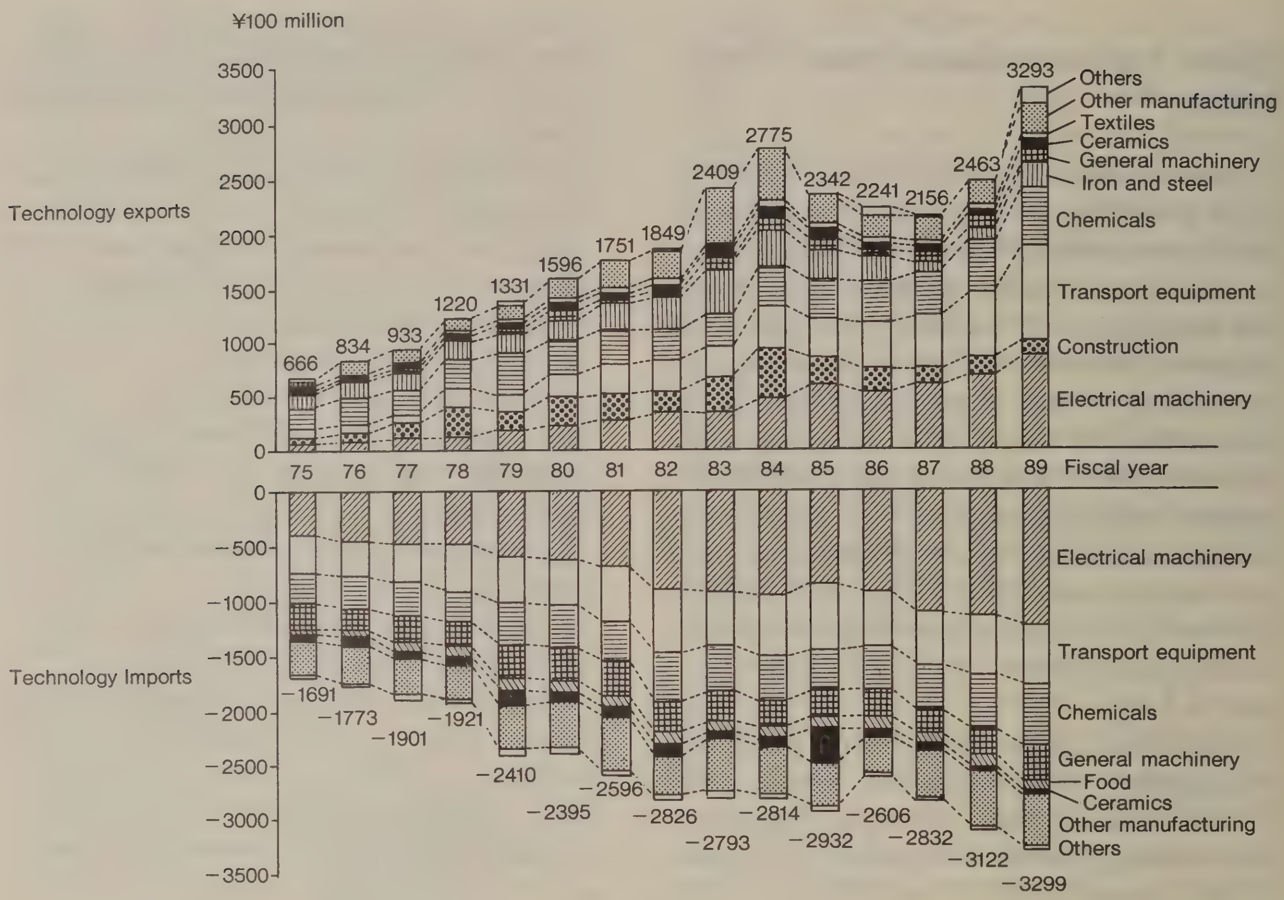


Figure 2-3-6. Trends in technology trade by industry sector

Source: "Report on the Survey of Research and Development", compiled by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 12)

which have a big share of the total R&D expenditures, are improving their technology trade balance (Figure 2-3-7). The number of newly introduced technologies was 2,898 in FY1989. This was an increase of 64 (2.3%) over the previous year.

The main sectors in which new technology was introduced are as follows:

- Electricity: 1,604 (55.3% of the total)
- Machinery: 383 (13.2%)
- Chemicals: 308 (10.6%)

The numbers of newly introduced technologies in the electricity field have been increasing gradually. Introduction of new technologies has been mostly from the United States, 1,808 (62.4% of the total), followed by countries such as United Kingdom, 196, Germany, 191, and France, 187. In high-tech fields, computer-related technologies, especially software, play an important role in the remarkable growth (Figure 2-3-8).

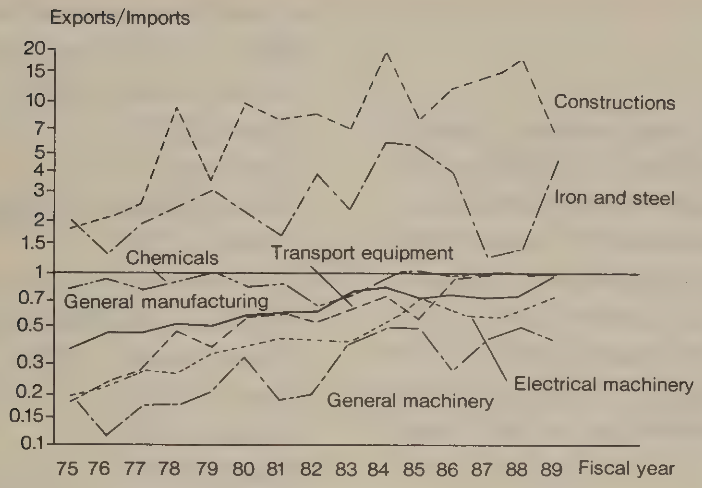


Figure 2-3-7. Trends in technology trade balance in major industry sectors

Source: "Report on the Survey of Research and Development", compiled by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 12)

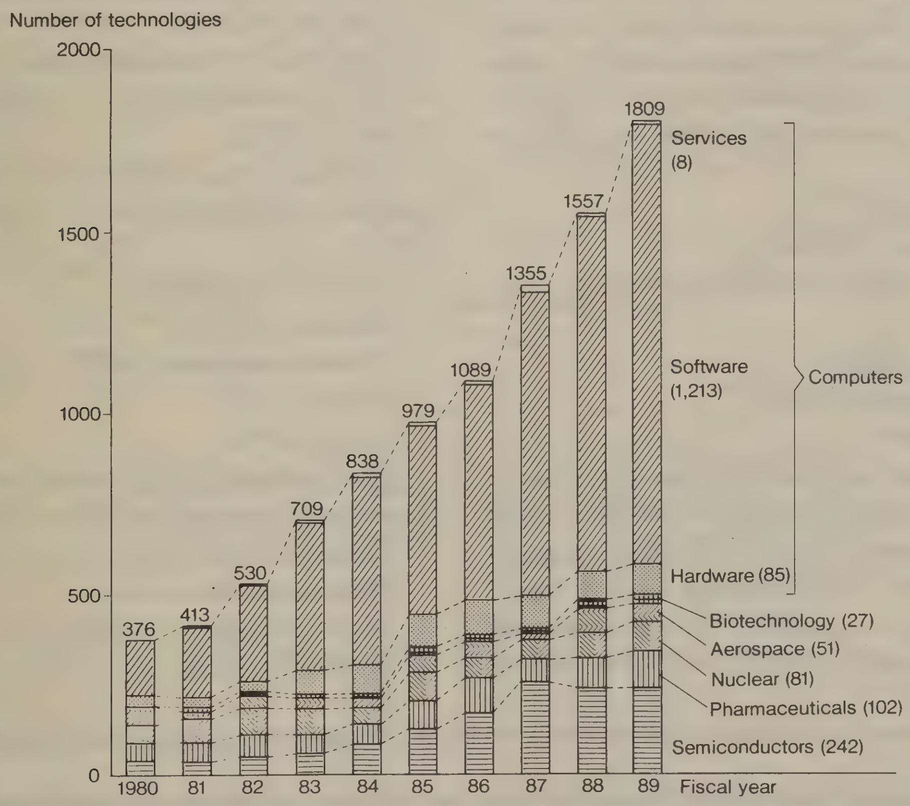


Figure 2-3-8. Trends in number of advanced technologies introduced into Japan

Source: "Foreign Technology Import Yearbook", compiled by the Science and Technology Agency (FY1980 - FY1986). "Summary of Foreign Technology Imports", compiled by the National Institute of Science and Technology Policy, Science and Technology Agency (FY1987 -)

2.3.2. Patents

Countries in which a large number of patents are applied for are countries in which private corporations and other organizations attach great importance to the protection of technologies: These countries can be considered to possess a great number of high technologies. Also, countries to which many patent applicants and inventors of granted patents belong are those where R&D and inventions are actively being carried out.

2.3.2.1. Patents in Selected Countries (Trends in Application and Registration)

Looking at the number of patents applied for in selected countries (including Patent Cooperation Treaty (PCT) applications[8] and European Patent Convention (EPC) applications[9]), Japan ranks at the top. The number of patents applied for in selected countries in 1989 follows: (Figure 2-3-9).

- Japan: 357,000
- United States: 162,000
- U.S.S.R.: 152,000 (including inventors' certificates)
- Germany: 102,000
- United Kingdom: 90,000
- France: 75,000

Regarding the nationality of patent applicants in selected countries, the ratio of foreign patent applicants is small in Japan (11.1%, in case of patents granted 13.5%). In the United States, where patents are applied for important and significant research results from everywhere in the world, the nationalities of patent applicants (1989) are as follows: (Table 2-3-10).

- United States: 51.3%
- Japan: 20.5%
- Germany: 8.2%
- United Kingdom: 4.0%
- France: 3.1%

U.S.-granted patents by nationality of inventor (1990) are as follows: (Figure 2-3-11).

- United States: 52.4%
- Japan: 21.6%
- Germany: 8.4%
- France: 3.2%
- United Kingdom: 3.1%

2.3.2.2. Patent Applications by Japanese in Foreign Countries

In 1989, the number of patents that were applied for in foreign countries by Japanese was 115,000 (including designations under the PCT and EPC applications), a five-year increase of 52,000 (81.9%).

The following shows the countries where patents were applied for by Japanese (Figure 2-3-12).

- United States: 28.8%
- Germany: 12.6%
- United Kingdom: 11.2%
- France: 9.4%
- Korea: 6.0%

The percentages of Japanese patent applicants in selected countries in 1989 were: (Table 2-3-13).

- United States: 20.5%
- France: 14.4%
- United Kingdom: 14.3%
- Germany: 14.1%

8) In 1978, the patent Cooperation Treaty (PCT) went into effect, by which it became possible for the applicant to apply for patents in more than one country (designated countries) at the same time, when he presents one application at one place. The unmber of PTC member countries is 45, as of January 1991.

9) In 1977, the European Patent Convention (EPC) went into effect, and since June 1978, the European Patent Office (EPO) has been processing European patent (EPC) applications. When a European patent is granted after an examination by the EPO, the patent has the same validity in the other EPC member countries designated by the applicant. The number of EPC member countries is 13, as of March 1990.

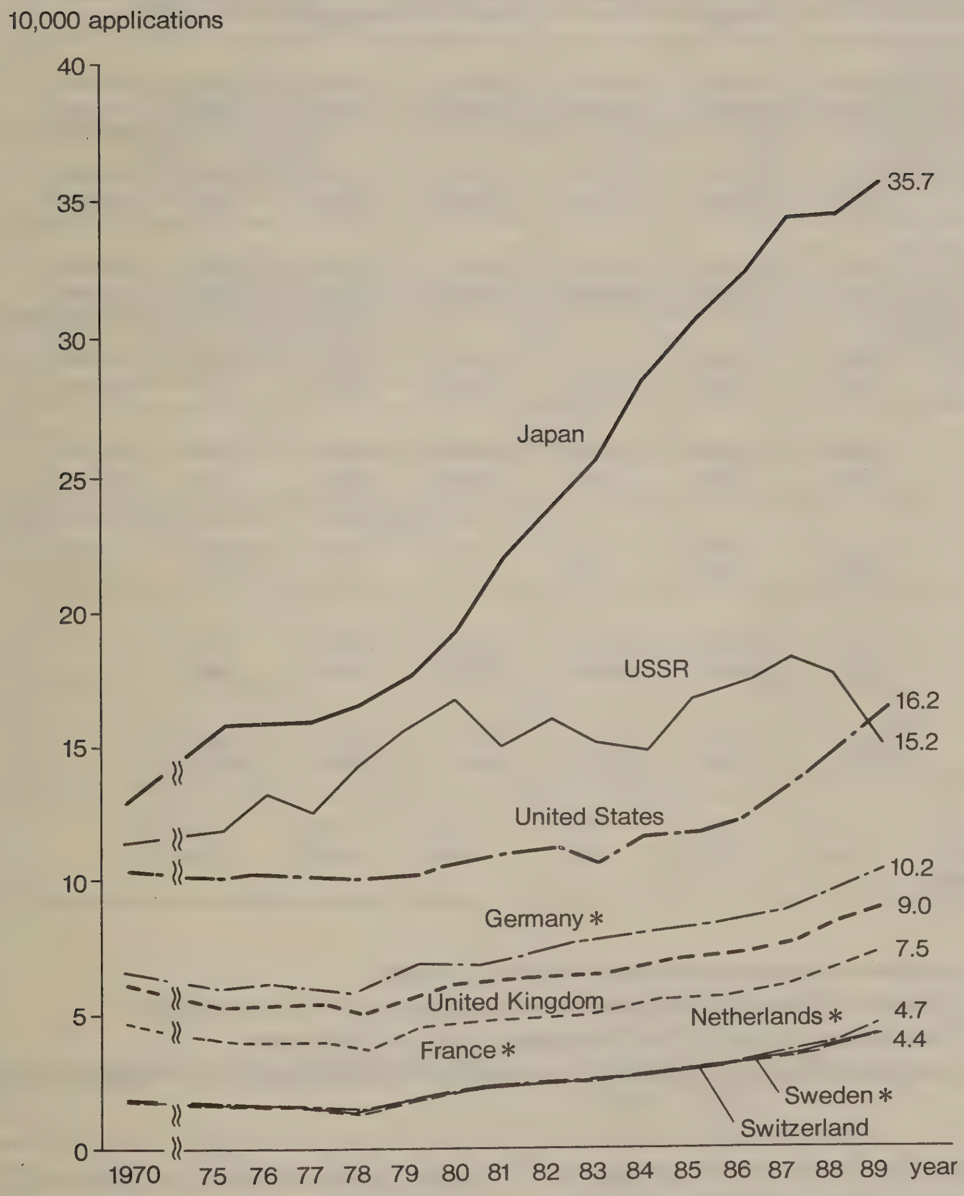


Figure 2-3-9. Trends in the number of patent applications in selected countries

Note: 1. Numbers of applications include applications under the Patent Cooperation Treaty (PCT) and the European Patent Convention (EPC).
2. " * " indicates EPC member countries.
3. The figure for the U.S.S.R. includes inventors' certificates.

Source: "Industrial Property Statistics" compiled by the World Intellectual Property Organization (WIPO) European Patent Office statistics also were used between 1979-1984.

Table 2-3-10.Number of patent applications (granted patents) in selected countries (1989)

Nationality of applicants	Country where patents were applied for						
	Japan	United States	Germany	France	United Kingdom	U.S.S.R.	Others
Japan	317,609 (54,743)	33,104 (20,168)	14,454 (6,888)	10,765 (4,294)	12,938 (5,440)	202 (102)	43,598 (13,932)
United States	17,563 (3,799)	82,956 (50,185)	18,693 (7,135)	17,483 (6,118)	19,598 (6,859)	1,664 (167)	161,087 (44,092)
Germany	7,436 (1,813)	13,345 (8,303)	43,265 (16,904)	13,471 (6,832)	13,075 (6,179)	830 (240)	87,999 (32,720)
France	2,624 (654)	4,960 (3,140)	5,115 (2,752)	15,468 (8,301)	4,920 (2,422)	291 (86)	37,545 (15,139)
United Kingdom	2,861 (432)	6,502 (3,100)	4,778 (1,637)	4,461 (1,471)	24,031 (4,234)	489 (50)	43,242 (10,470)
U.S.S.R.	357 (108)	570 (161)	459 (227)	365 (126)	403 (87)	146,021 (83,348)	5,420 (1,552)
Others	9,014 (1,752)	20,323 (10,482)	15,663 (16,690)	12,929 (5,737)	15,269 (5,676)	2,311 (584)	-
Total	357,464 (63,301)	161,660 (95,539)	102,427 (42,233)	74,942 (32,879)	90,234 (30,897)	151,808 (84,577)	-
Percentage of foreign nationalities	11.1 (13.5)	48.7 (47.5)	57.8 (60.0)	79.4 (74.8)	73.4 (86.3)	3.8 (1.5)	-

Note: 1. Numbers in parentheses refer to granted patents.
2. These data include designated countries under the PCT and the EPC.
3. The figures for the U.S.S.R. includes inventors' certificates.

Source: "Industrial Property Statistics" compiled by the World Intellectual Property Organization

2.3.2.3. Trends in Patent Applications in Japan

The number of patent applications in Japan has been increasing. This is due to an improvement in the level of technology and to the impetus of active R&D. In 1990, the number of patent applications was 368,000 (a 4.7% increase over the previous year). The number of applications for utility models was 138,000 (a 9.8% decrease over the previous year).

Numbers of patent applications in 1989 by technical classification[10] are as follows:

- Physics: 94,000 (27.1% of the total application)
- Electricity: 85,000 (24.7%)

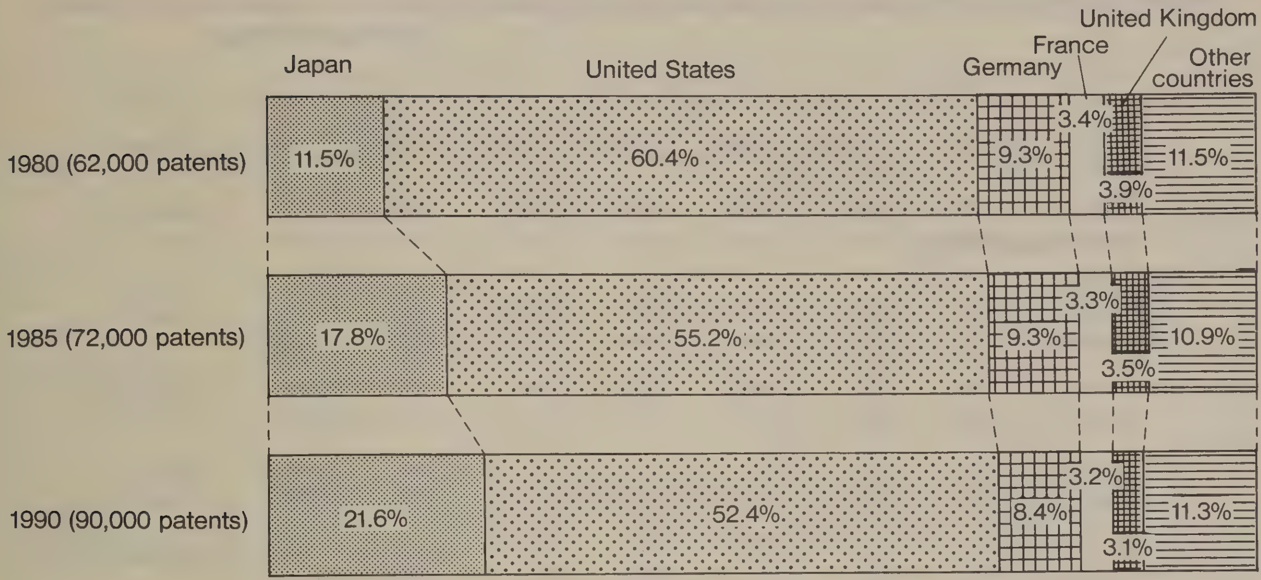


Figure 2-3-11. U.S. granted patents by nationality of inventor

Source: United States Patent and Trademark Office

- Processing, operations, transportation: 59,000 (17.0%)

Numbers of patent applications by foreign inventors have increased slightly during the last few years. In 1990, there were 34,000 applications (9.3% of the total). A breakdown of patent applications by nationality of inventor is as follows: (Figure 2-3-14).

- United States: 46.1%
- Germany: 17.0%
- France: 7.2%
- United Kingdom: 5.6%

A breakdown of patent applications by foreign inventors in 1990 by field is as follows:

- Chemicals, metals, textiles: 31.4%
- Processing, operations, transportation: 17.7%
- Physics: 15.7%
- Electricity: 14.5%

10) Technical classification of an individual application of patent or utility model is arranged approximately one year after the application has been filed.

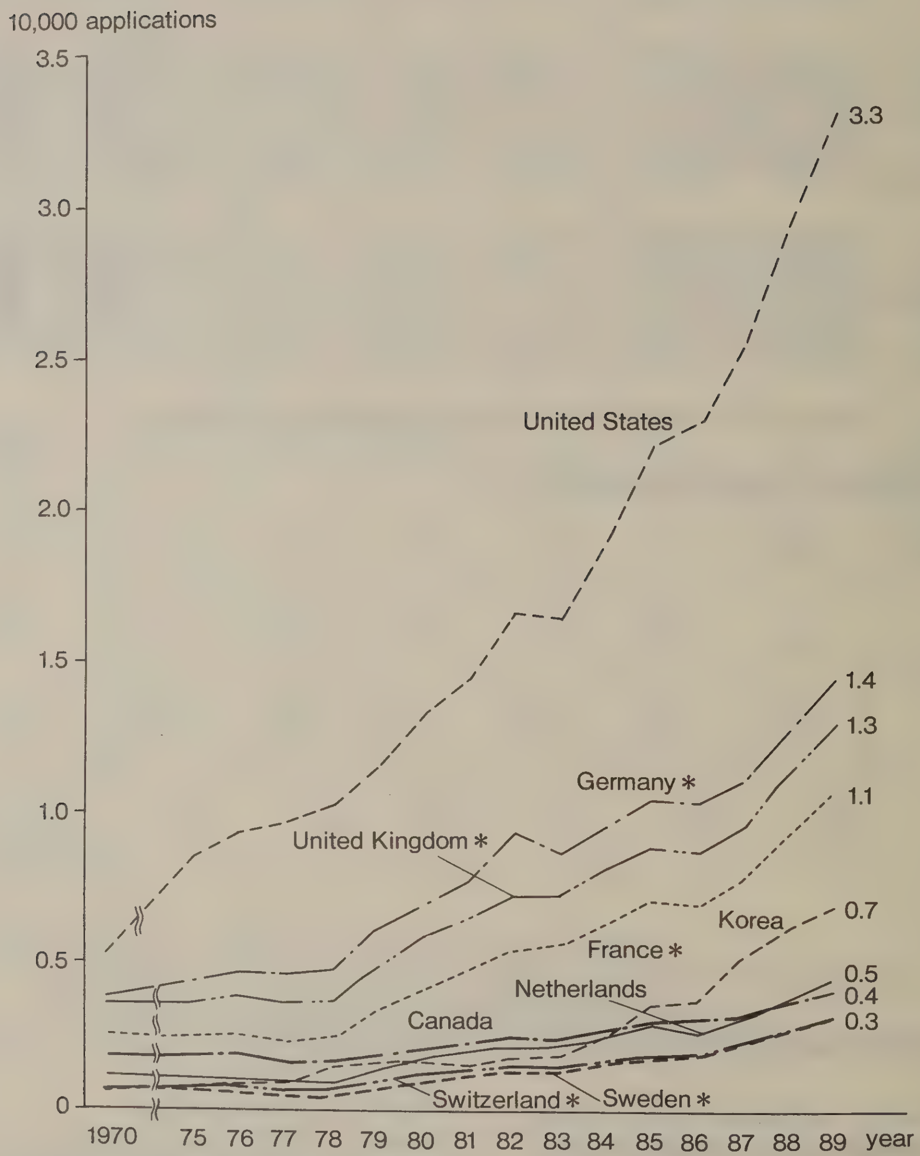


Figure 2-3-12.Trends in number of patent applications in foreign countries by Japanese

Note: 1. Numbers of applications include applications under the Patent Cooperation Treaty (PCT) and the European Patent Convention (EPC).
2. "*" indicates EPC member countries.

Source: Same as in Figure 2-3-9.

Table 2-3-13.Changes in the ratio of Japanese in patent applications(granted patents) in selected countries (unit: %)

Year / Country	1970	1975	1980	1985	1986	1987	1988	1989
United States	5.1 (4.1)	8.5 (8.8)	12.4 (11.6)	18.9 (17.8)	18.7 (18.6)	19.1 (20.0)	20.1 (20.7)	20.5 (21.1)
Germany	5.8 (3.2)	7.2 (9.5)	10.3 (11.4)	12.5 (14.4)	12.0 (14.6)	12.5 (15.1)	13.4 (15.5)	14.1 (16.3)
France	5.3 (3.8)	6.0 (6.0)	8.9 (6.7)	12.6 (11.7)	11.8 (12.6)	12.6 (12.2)	13.7 (12.5)	14.4 (13.1)
United Kingdom	5.8 (5.6)	6.8 (9.0)	9.6 (9.4)	12.6 (17.2)	11.9 (16.7)	12.5 (16.8)	13.5 (17.0)	14.3 (17.6)
Netherlands	6.5 (3.9)	6.4 (9.5)	8.3 (11.8)	9.3 (9.9)	8.0 (9.7)	8.6 (10.0)	9.1 (9.8)	9.5 (10.0)
Sweden	3.2 (1.5)	3.9 (3.7)	4.5 (4.6)	5.9 (6.3)	5.5 (6.6)	6.4 (6.3)	7.2 (6.5)	7.4 (6.4)
Switersland	3.4 (2.4)	4.1 (4.6)	5.6 (6.2)	6.4 (7.9)	6.0 (7.0)	6.8 (7.0)	7.1 (6.5)	7.3 (6.6)
Korea	- -	24.2 -	32.0 (44.4)	30.1 (35.8)	26.6 (44.5)	27.7 (41.6)	27.2 (35.1)	26.0 (35.5)
Canada	5.8 (3.4)	6.8 (6.5)	8.1 (7.8)	11.1 (10.9)	11.2 (11.3)	10.9 (10.7)	11.8 (11.9)	11.6 (12.8)

Source: "Industrial Property Statistics" compiled by the World Intellectual Property Organization (WIPO) European Patent Office statistics are used in addition only for 1980.

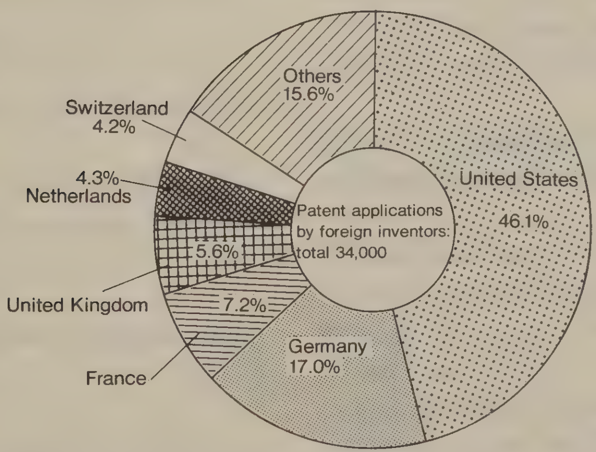


Figure 2-3-14. Share of patent applications in Japan by nationality of foreign inventor (1990 total: 34,000)

Source: "Patent Agency Yearbook" compiled by the Patent Agency

Part 3.
Science and Technology Policy Development in Japan

3.1. Outline of Science and Technology Policy in Japan

3.1.1. General Guideline for Science and Technology Policy

In March 1986, the Cabinet approved *The General Guideline for Science and Technology Policy,* based on a recommendation submitted by the Council for Science and Technology (CST), in order to dynamically and organically promote Japanese science and technology from a longer standpoint. *The General Guideline* provides for the following spheres of activity.

- Promoting highly creative science and technology centered on reinforcing basic research
- Emphasizing the international aspect of science and technology
- Developing science and technology in harmony with man and society

The General Guideline also provided for a series of basic R&D plans, each intended to encourage a specific area.

Several themes have been developed from *The General Guideline,* and these are described in the sections below.

3.1.1.1. Promoting Creative Science and Technology

The General Guideline makes the following recommendations to ensure continuing creativity in the nation's scientific research.

- Providing systematic support for the activities of national research institutes
- Increasing R&D investment
- Securing and training R&D personnel
- Consolidating the basis for science and technology promotion

Several measures have been devised to implement these recommendations. Specially, the government has identified a number of important areas of research and development which should be promoted. Of these, seven fields in basic, leading science and technologies are being given particular encouragement.

- Materials science and technology
- Information/electronics science and technology
- Life sciences
- Soft science and technology
- Space science and technology
- Ocean science and technology
- Earth science and technology

Various programs currently are being implemented in each of these areas.

3.1.1.2. Emphasizing the International Aspect of Science and Technology

Japan has been encouraged by international trends to expand its role in the world community by furthering international exchange and cooperation.

The Human Frontier Science Program and *The Space Station Program* are two recent examples of greater bilateral or multilateral cooperation between Japan and the industrialized countries. Another example is the newly established Fellowship Program to expand

international exchange by inviting researchers from abroad to conduct research at research institutes and laboratories in Japan.

3.1.1.3. Developing Science and Technology in Harmony with Man and Society

In addition to the advancement of basic and leading science and technology fields, *The General Guideline* also identifies as important areas of R&D, areas related to activating the economy and to improving the quality of society and life.

Promotional objectives within these fields include the following.

- Recycling and effective utilization of resources
- Improvement of service to society and life
- Maintaining and improving the mental and physical health of the people
- Formulating an individual and cultural life
- Formulating a comfortable and safe society
- Improving the human environment based on a global viewpoint

Recent changes both at home and abroad have demonstrated the need for an updated general policy on science and technology. On June 22, 1990, the Prime Minister requested the CST to conduct an inquiry and report its findings on *General Basic Policies on Science and Technology for the Next Century.*

3.1.2. The Council for Science and Technology

The Council for Science and Technology (CST) was established in February 1959 to comprehensively promote overall science and technology policies of the government as the supreme deliberative science and technology policy organization. Under the terms of the Establishment Law of the Council for Science and Technology, the CST is an advisory body to the Prime Minister supervised by the Prime Minister's Office. It is chaired by the Prime Minister and its members include cabinet ministers dealing with science and technology and distinguished experts in various fields.

The CST's main task is to advise to the Prime Minister in the following.

- Establishment of general basic science and technology policy
- Establishment of comprehensive long-term research goals
- Formulation of basic guidelines for promoting specific research areas aimed at achieving these goals

The CST recommends findings on inquiries to the Prime Minister and, when appropriate, submits CST-initiated advice (Table 3-1-1).

The CST Committee on Policy Matters, composed of distinguished experts from various fields,manages important matters in a timely and appropriate manner and designs and develops flexible science and technology policy.

The tasks of the Committee is as follows.

- Decide the direction for discussions on a recommendation
- Set the guidelines for expenditures of the Special Coordination Funds for Promoting Science and Technology
- Decide on priorities for promoting science and technology
- Direct basic investigations for guideline on planning science and technology policies

3.1.2.1. The Formulation of General Basic Policy

3.1.2.1.1. Recommendation Pursuant to Inquiry No. 11 *Comprehensive Fundamental Policy for Promotion of Science and Technology to cope with Current Changing Situations from a Long-Term View;* submitted on November 27,1984

The CST Recommendation pursuant to Inquiry No. 11 makes fundamental recommendations on science and technology which have subsequently become the cornerstone of the government's current, 10-year science and

Table 3-1-1. Outline of major recommendations by the Council for Science and Technology

Title	Date	Outline
Recommendation for Inquiry No. 9 "basic program for R&D on disaster prevention"	July 6, 1981	In order to prevent disasters due to meteorological phenomena, control the expansion of damage in case disasters have occurred and achieve recovery from disasters, the recommendation suggests the R&D areas and objectives concerning disaster prevention science and technology to be strongly promoted for a long period by the initiative of the government.
Recommendation for Inquiry No. 10 "basic plan for R&D on life sciences"	April 24, 1984	In order to develop more comprehensively, systematically and efficiently those technologies rapidly progressing in recent years which manipulate so-called genetic information systems of organisms such as DNA recombination and cell fusion, the recommendation suggests the R&D areas and objectives to be emphasized for the time being and the promotion measures to achieve the objectives.
Recommendation for Inquiry No. 13 "intermediate and long-range basic policy for national research institutes"	August 28, 1987	Taking into consideration the changes in conditions surrounding national research institutes and the problems which they are facing, the recommendation suggests desirable medium- and long-term prospects for their future roles and ways to activate these roles.
Recommendation for Inquiry No. 14 "basic plan for R&D on Materials S&T"	August 28, 1987	In order to contribute to the comprehensive and systematic promotion activities in the future concerning materials science and technology, which has been rapidly progressing in recent years, the recommendation suggests significant R&D objectives and promotion measures for the next 10 years.
Recommendation for Inquiry No. 15 "basic plan for R&D on Information/Electronics S&T"	March 14, 1989	With respect to information/electronics science and technology rapidly progressing in recent years, the recommendation suggests expectations of this sort of science and technology, significant R&D tasks and promotion measures for the next 10 years.
Recommendation for inquiry No. 16 "comprehensive basic policy for upgrading and strengthening the infrastructure to support S&T"	December 5, 1989	With respect to production and distribution of science and technology information, development, installation and provision of instruments and equipment and development, storage and supply of materials, genetic resources, etc. as well as research supporting functions as an environmental condition for activating fundamental activities and intellectual properties, the recommendation suggests the fundamental guidelines for constructing the infrastructure to support of science and technology.

Note: Excluding recommendations described in the text.

technology policy.

This report specifies three basic principles of activity as crucial building-blocks for the cultural enrichment and socioeconomic improvement to be achieved through the general development of science and technology.

- Promoting highly creative science and technology centered on reinforcing basic research
- Developing science and technology emphasizing their international aspects
- Harmonizing science and technology with man and society

Following this, the CST submitted its Recommendation pursuant to Inquiry No. 12, *General Guideline for Science and Technology Policy,* on December 3, 1985.

This recommendation deals with issues that have surfaced subsequent to the submission of the Recommendation based on Inquiry No. 11. Further, the objectives stated in the earlier recommendation are reworked into concrete recommendations for key administrative-level goals for the promotion of science and technology.

The Cabinet adopted the Recommendation pursuant to Inquiry No. 12 and approved *The General Guideline for Science and Technology Policy* in March 1986.

3.1.2.1.2. Inquiry No. 18 *General Basic Policies on Science and Technology for the Next Century;* submitted on June 22, 1990

Major changes in the situation both at home and abroad necessitated the formulation of a new general science and technology policy. Changes in the situation abroad included the easing of East-West tensions and the movement among the members of the European Communities (EC) toward unification. Changes in the situation at home included fast-paced structural changes in the economic sector, rising expectations for improvements in the standard of living, and the aging of society.

On June 22, 1990, the Prime Minister presented Inquiry No. 18 to the CST, requesting recommendations for 10-year science and technology policies to follow on from those implemented as the result of Recommendations No. 11 and 12.

In response to the inquiry, the CST set up a General Planning Subcommittee, a Subcommittee on Important Research and Development Areas, a Personnel Subcommittee and a Subcommittee on Research and Development Investment. Investigations and deliberations are being conducted mainly by its Panel on General Planning.

3.1.2.2. Basic Plan for Important Areas of Research and Development

3.1.2.2.1. Recommendation Pursuant to Inquiry No.17 *Basic Plan for R&D on Earth Science and Technology;* submitted on June 22, 1990

Problems such as the destruction of the ozone layer and global warming, both of which were discussed at the 「Arché」 Summit, demonstrate how major consequences can accompany global environmental problems.

In March 1989, the Prime Minister presented Inquiry No. 17 to the CST, requesting recommendations for formulating basic R&D plans that, if acted upon, would help to increase the knowledge of our planet and contribute to worldwide prosperity.

The CST formulated its recommendation at the plenary session on June 22, 1990, and submitted it to the Prime Minister. The recommendation was approved by the Prime Minister as *The Basic Plan for R&D on Earth Science and Technology* on August 20, 1990.

The recommendation suggests the need to understand the earth as a total system, and sets up the "human activities sphere" besides other spheres like the geosphere and hydrosphere.

The report's recommendations cover a period of ten years and address the following spheres of activity.

- Promotion of R&D on earth science and technology as a comprehensive system
- Orientation toward science and technology in which a proper balance between man and nature is maintained.
- Promotion of R&D focused on Asia and the Western Pacific.

The recommendation also identifies a number of key R&D subjects and presents the government's role and tasks.

3.1.2.2.2. Inquiry No. 19 *Basic Plan for R&D on Soft Science and Technology* submitted on January 22, 1991

Under the circumstances where science and technology become increasingly sophisticated and complex, it has become an important task for us to derive potentials of science and technology

and make them contribute to the solution of complicated social problems. Soft science and technology, which is positioned as an important R&D area in *The General Guideline for Science and Technology Policy,* is not only quite effective in solving these problems and essential for making full use of hardware functions, but also is significant in analyzing the mutual relations of various elements in humanistic and social phenomena. On the other hand, due to recent progress of R&D in such relevant area as information and electronic science and technology, the fundamental environment for developing soft science and technology has been maturing. Under these circumstances, in January 1991, the Prime Minister considered the need to promote planned R&D of soft science and technology in wide-ranging areas and made an inquiry to the CST concerning basic R&D plans for soft science and technology. In response to the inquiry, the CST has set up a new Subcommittee for Soft Science and Technology and is now conducting investigations.

3.1.2.3. Comprehensive Coordination of Policies for Science and Technology Promotion

3.1.2.3.1. The Special Coordination Funds for Promoting Science and Technology (SCF)

The SCF were first established in FY1981 to facilitate the comprehensive promotion of science and technology as a funded system; they are expended in accordance with the guidelines decided by the CST. Administration of the SCF is based on a policy document entitled *The Basic Guideline for Allocation of the Special Coordination Funds for Promoting Science and Technology* which was adopted by the CST in March 1981. More specifically, the SCF are expended in accordance with the annual guideline of the CST Policy Committee.

Joint research utilizing scientific and technological potential in the region and the Special Researcher System for Science and Technology were started in FY1990, and the International Workshop Support Program was launched in FY1991.

3.1.2.3.2. Guideline on the Priority for Promoting Science and Technology

The Committee on Policy Matters decides annually the Guideline on the priority for promoting science and technology along the line with *The General Guideline for Science and Technology Policy.*

The Guideline on the priority for promoting science and technology in FY1991 was decided in July 1990 and stresses the following areas.

(i) strengthening the measures to increase young research personnel in universities, national research institutions, etc. and to cultivate originality of individual researchers;
(ii) bolstering and strengthening international joint studies and projects which put emphasis on the initiative of our country;
(iii) strengthening the basis for promoting science and technology, which includes the construction of databases and formation of networks and other means of collection, processing and supply of science and technology information

3.1.2.3.3. Basic Investigations for Planning Science and Technology Policies

The Sub-committee on Policy Studies under the Committee on Policy Matters undertakes background investigations and analyses in areas deemed essential to the formulation of policies for comprehensive and effective R&D promotion. Investigations are financed with appropriations from the SCF.

In FY1990, the following investigations were continued from the previous year.

- Investigation on the direction of development in advanced science and technology fields
- Investigations into improving the conditions for the promotion of basic and leading science and technology

- As a part of basic investigations, an annual forum on science and technology has been held. In FY1990, the 10th Forum on Science and Technology was held in January 1991 with the theme of "Towards Science and Technology in Harmony with Humanity".

3.1.2.4. Follow-up Activities for CST Recommendations

Follow-up activities for CST recommendations are conducted in the Committee on Policy Matters to realize the policies recommended and to coordinate the science and technology policies.

In July 1985, the Subcommittee on the Life Sciences set up the Ad-hoc Committee on Life Sciences and Human Being. The Committee, with members who are experts in the biological and medical fields, as well as in the humanities and social sciences, was organized to follow up on the theme of *Development of Science and Technology in Harmony with Man and Society* presented in the Recommendation on Inquiry No. 11.

The Committee explored the effects of advances in the life sciences on individuals and society and highlighted the major issues concerned. The Committee submitted a summary of its deliberations in June 1990.

Similarly, the Ad-hoc Committee on Cooperation in Research between Industrial, National University and Government Facilities submitted a report on its findings in March 1990.

3.1.2.5. International Development

The rapid changes in the international situation around Japan have resulted in the recognition that the necessity to contribute to the international society in the field of science and technology is much more than ever before.

High level policy matters dealing with, for example, the ideal method of carrying out large-scale international cooperation and long-term R&D, and global environmental issues also have rapidly increased.

Therefore, the CST also has been required to use its own judgement to develop international activities in a more active manner.

3.1.2.5.1. Ad-hoc Committee on International Affairs

In line with what was mentioned above, in November 1987, the Committee on Policy Matters set up the Ad-hoc Committee on International Affairs to discuss basic perspectives on the various international relationships around science and technology field.

In FY1990, the Ad-hoc Committee set up a study group to conduct investigations and deliberations mainly of international contributions in the area of science and technology. It finalized in June 1990 a report entitled "Performance of International Contributions concerning Science and Technology in Japan". In December 1990, the committee concluded a report entitled "Toward the Globalization of Science and Technology". The report advocated (i) the further promotion of public disclosure, distribution and transfer of results of science and technology; and (ii) the development of science and technology on a global scale through international cooperation to cope with common problems of mankind, and increasing the scale and diversification of science and technology, in other words, the "Globalization of Science and Technology".

3.1.2.5.2. International Invitation Meeting of the CST

As seen in the promotion activities for solving common problems of mankind and for large-scale international joint projects, international coordination in science and technology policy has become increasingly important in recent years. Under these circumstances, the CST started from FY1990 *The International Invitation Meeting*. Important persons from abroad involved in science and technology policy

are being invited to exchange opinions with members of the Committee on Policy Matters of the CST. In FY1990, Mr. McTague, a member of the President's Council of Advisers on Science and Technology (PCAST), and Mr. Fasella, President, the Science and Technical Research Committee (CREST) of the EC, were invited in January 1991. Science and technology policies in the countries concerned were introduced and opinions concerning international science and technology policy were exchanged.

3.1.2.5.3. International Exchange of Views on Science and Technology Policy

3.1.2.5.3.1. Japan and the EC

In response to the proposal in the 1984 Japan-EC high-level consultations, the CST and the EC commission have exchanged views on science and technology policy. The fourth round of discussions was held in Brussels in March 1990.

3.1.2.5.3.2. International Conferences

A CST member participated in discussions on international cooperation in science and technology at the 9th Meeting of Presidents of Research Councils of Canada, Europe, Japan, and the USA (Scientist Summit) held in Munich in 1990.

3.2. Structures for Promotion of Science and Technology

3.2.1. Administrative Structure

In principle, each government ministry or agency has jurisdiction over the promotion of its own science and technology programs. Research is carried out at relevant national research institutes, public research corporations and national universities, including inter-university research institutes.

For example, the Ministry of Education administers academic research programs; the Ministry of Health and Welfare conducts research with the goal of improving health and social welfare; the Ministry of Agriculture, Forestry and Fisheries carries on research for the nation's agriculture, forestry and fishing; the Ministry of International Trade and Industry carries on mining and industry research; the Ministry of Transport has jurisdiction over transport-related research programs; and the Ministry of Posts and Telecommunications oversees telecommunications research (Figure 3-2-1).

The Science and Technology Agency has the responsibility to ensure that all government-sponsored science and technology promotion measures are conducted expediently and effectively, and that the goals of research programs are adequately balanced from the standpoint of national development.

The Agency coordinates budget requests and estimates for the national research institutes. Moreover, the Agency oversees the management of the Special Coordination Funds for Promoting Science and Technology. The Agency, however, has no jurisdiction over science and technology research carried out at universities and colleges, nor for research programs related solely with humanities.

Some institutions, such as the Japan Key Technology Center, the Bio-oriented Technology

Figure 3-2-1. Administrative Structure (July 1991)

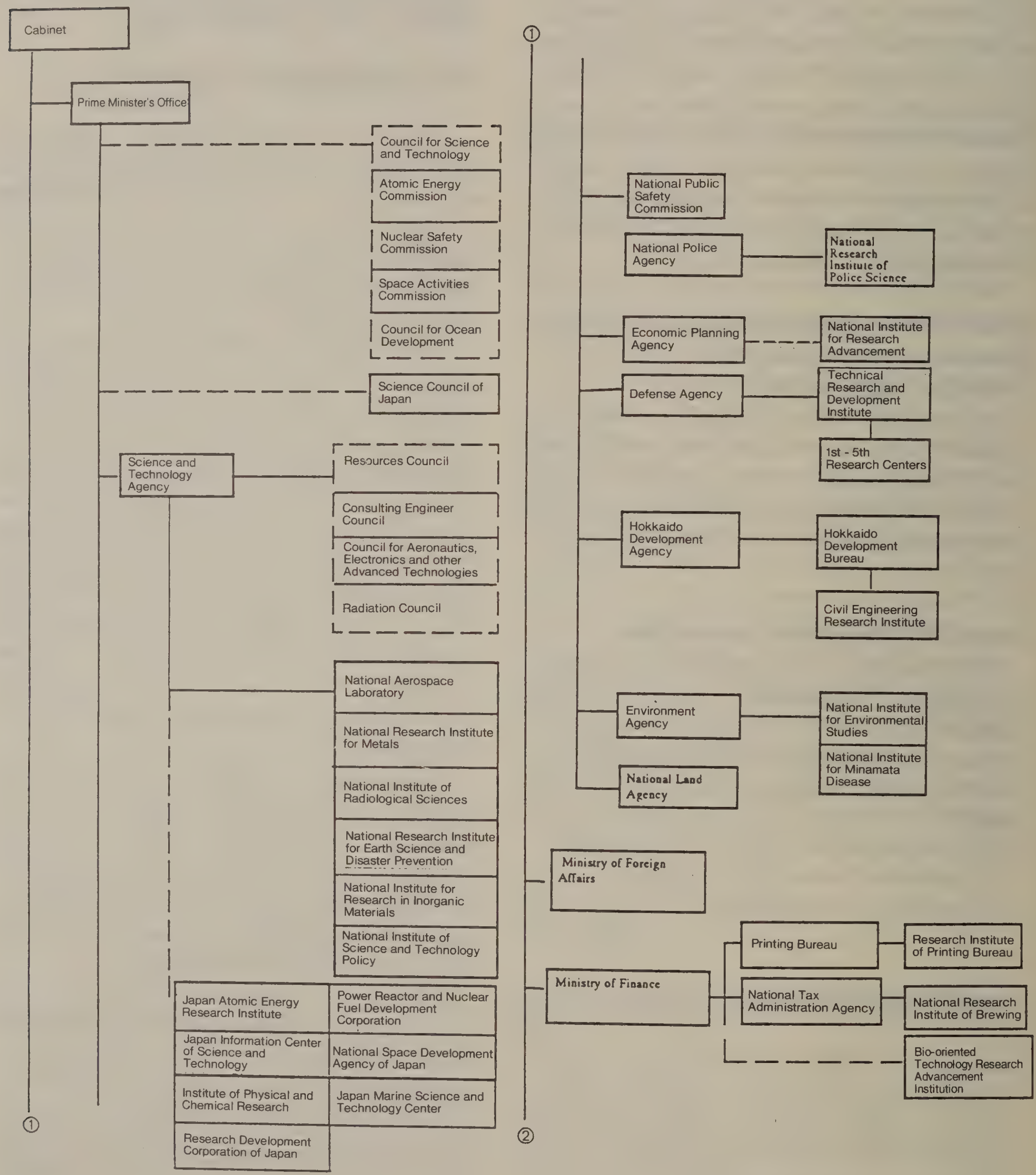


Figure 3-2-1. Administrative Structure (July 1991)

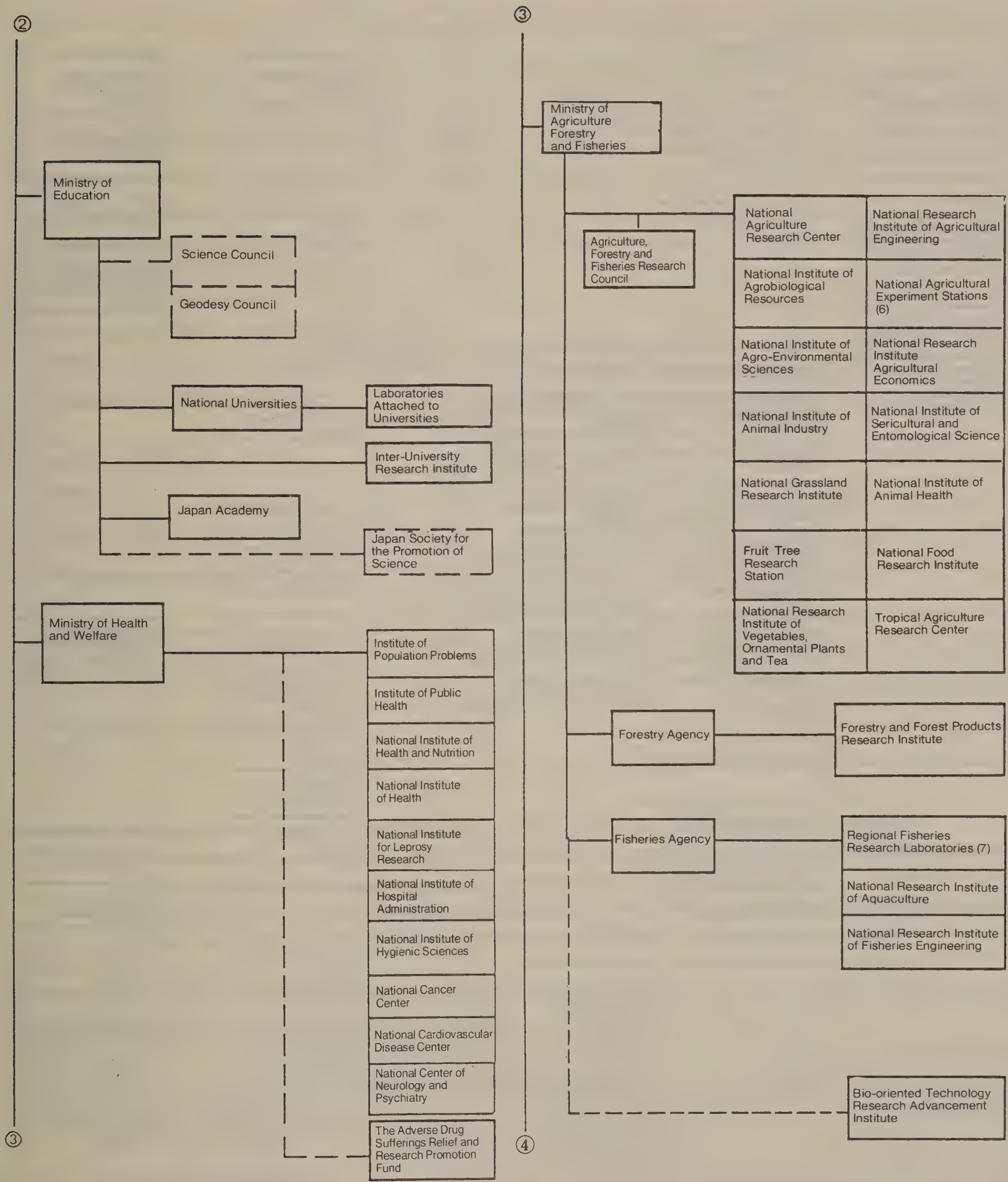


Figure 3-2-1. Administrative Structure (July 1991)

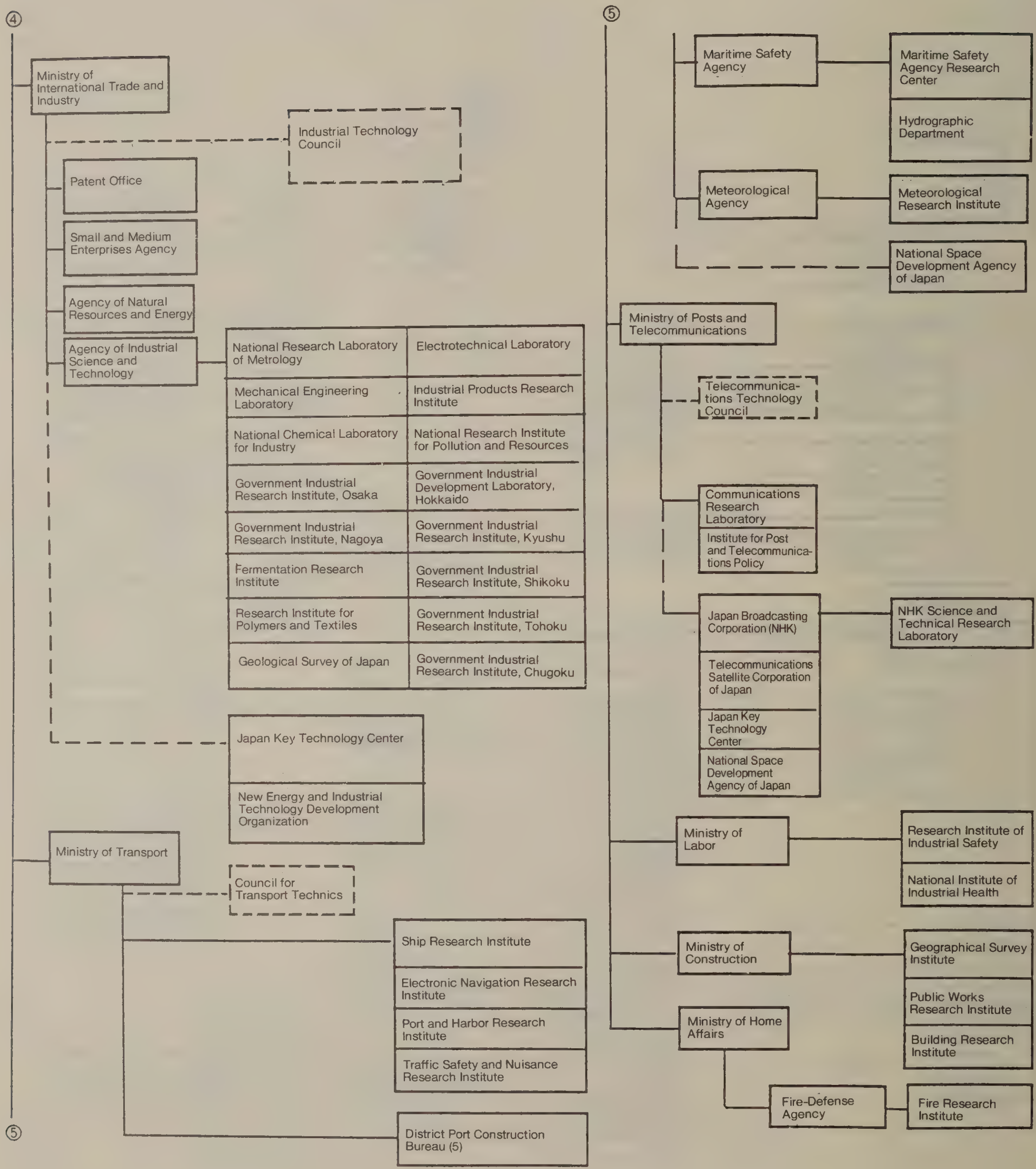


Table 3-2-2. Science and technology budget allocations--1987 to 1991 (¥ 100 million)

Item		Fiscal Year 1987	1988	1989	1990	1991
Science and Technology Promotion Fund	(A)	4,006	4,173	4,480	4,755	5,074
Percentage increase over the previous year	%	2.5	4.2	7.4	6.1	6.7
Research appropriations other than those earmarked in the Science and Technology Promotion Fund	(B)	12,617	12,984	13,676	14,454	15,153
Percentage increase over the previous year	%	3.8	2.9	5.3	5.7	4.8
Science and Technology Budget	(C) = (A)+(B)	16,623	17,157	18,156	19,209	20,226
Percentage increase over the previous year	%	3.5	3.2	5.8	5.8	5.3
General Account Budget	(D)	541,010	566,997	604,142	662,368	703,474
Percentage increase over the previous year	%	0.0	4.8	6.6	9.6	6.2
(C) ÷ (D) x 100	%	3.07	3.03	3.01	2.90	2.88
General Budget Expenditure	(E)	325,834	329,821	340,805	353,731	370,365
Percentage increase over the previous year	%	0.0	1.2	3.3	3.8	4.7

Note: 1. All amounts represent initial budgets or appropriations for the respective fiscal year.
2. Since amounts have been rounded, the sum of the amounts and percentages for each column, and the totals and percentages shown above do not necessarily agree.
3. Amounts shown for research appropriations other than those earmarked in the Science and Technology Promotion Fund(B) are Science and Technology Agency estimates.

Research Advancement Institution, the Adverse Drug Sufferings Relief and Research Promotion Fund, and the New Energy and Industrial Technology Development Organization, support R&D activities in the private sector.

3.2.2. Budget Allocations

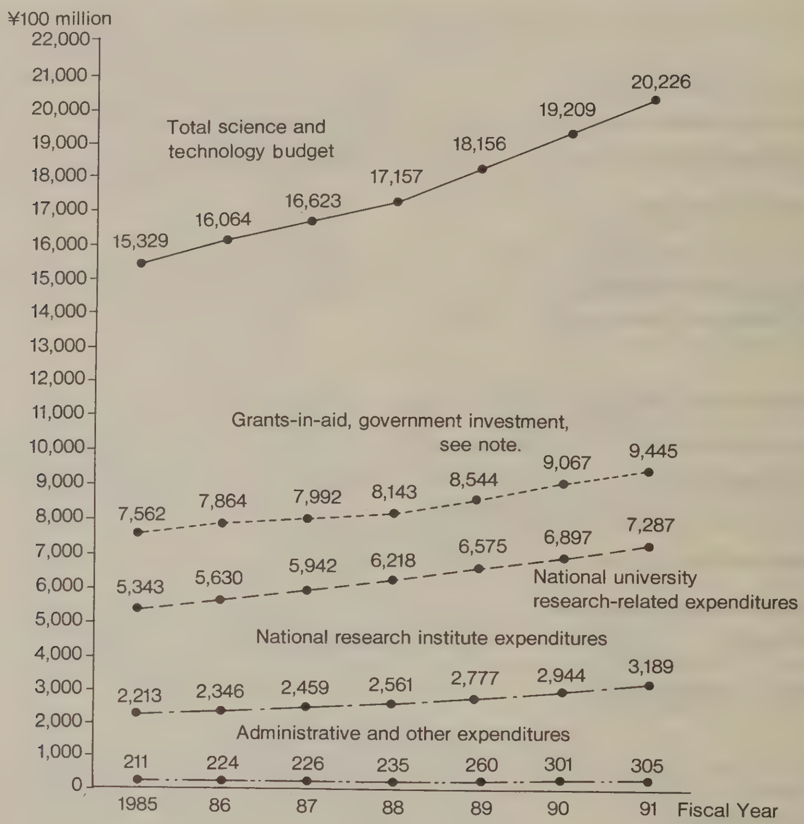
In FY1991, the national science and technology budget[1)] totaled 2.0226 trillion yen, up 5.3% from the preceding year.

Compared to the previous year, the FY1991 General Account Budget rose 6.2% and the General Budget Expenditure[2)] increased by 4.7% (Table 3-2-2).

In FY1991, expenditures for the science and technology promotion fund were 507.4 billion yen, up 6.7%, and other research-related expend-

1) This figure is a Science and Technology Agency estimate.
2) That is, the General Account Budget less payments on government bonds, subsidies to local governments and the amount transferred to the special account for industrial investment.

Figure 3-2-3. Changes in research budgets earmarked in the Science and Technology Budget



Note: In addition to grants-in-aid, the above amounts include commissioned project costs, investments (financing) and share of the expenses.

itures primarily at national universities were 1,515.3 billion yen, up 4.8%.

Figure 3-2-3 shows trends in research allocations from the science and technology budget over the last seven years.

As shown in Figure 3-2-3, FY1991 expenditures for the national research institutes, including costs of research, personnel and facilities, totaled 318.9 billion yen, up 8.3%. Grants-in-aid, commissioned project costs, investments and shared costs were 944.5 billion yen, a 4.2% increase over the preceding year and accounted for 46.7% of the total science and technology budget. This expenditure consists of government support for large R&D projects, grants-in-aid and commissioned project costs to public research corporations and the private sector. Table 3-2-4 provides the breakdown of the science and technology budgets for FY1990 and 1991 by government ministries or agencies. Table 3-2-5 compares the overall trend in allocations for science and technology in the budgets of five selected countries. However, since fiscal accounting procedures differ from country to country, it is difficult to make direct comparisons, particularly regarding the actual amounts of money allocated.

Table 3-2-4. Science and technology budget breakdown by ministries and agencies--(¥ million)

Ministry or agency	Fiscal Year	
	1990	1991
Diet	533	533
Science Council of Japan	951	1,051
National Police Agency	1,055	1,143
Hokkaido Development Agency	149	148
Defence Agency	104,268	115,045
Economic Planning Agency	809	850
Science and Technology Agency *	494,775	522,561
Environment Agency	9,217	10,900
Ministry of Justice	939	1,006
Ministry of Foreign Affairs	7,095	8,160
Ministry of Finance *	1,087	1,193
Ministry of Education *	894,301	936,324
Ministry of Health and Welfare *	51,242	56,144
Ministry of Agriculture, Forestry and Fisheries *	70,108	73,557
Ministry of International Trade and Industry *	251,548	255,913
Ministry of Transport *	17,402	20,514
Ministry of Posts and Telecommunications *	30,657	33,904
Ministry of Labor *	4,190	5,046
Ministry of Construction	5,979	6,624
Ministry of Home Affairs	565	616
Total	1,920,871	2,022,631

Note: 1. All amounts represent initial budgets or appropriations for the respective fiscal year.
2. Since amounts have been rounded off, the sum of the amounts for each column, and the totals shown above do not necessarily agree.
3. Some amounts include appropriations for humanities.
4. The amounts for the ministries and agency marked with asterisks include the Science and Technology Budget appropriations from Special Accounts.

Table 3-2-5. Science and technology budgets of selected countries

Country		Fiscal Year				
		1986	1987	1988	1989	1990
Japan	¥100 million	16,064	16,623	17,157	18,156	19,209
	Percentage of the Science and Technology Budget in the General Account Budget	2.97	3.07	3.03	3.01	2.90
United States	US$ million	52,141	53,256	56,100	60,760	63,810
	¥100 million	87,858	77,008	71,920	83,849	92,397
	Percentage of the science and technology allocation in the national budget	5.3	5.3	5.3	5.3	5.1
Germany	DM. million	12,898	13,144	13,255	14,017	15,312
	¥100 million	10,010	10,577	9,672	10,286	13,721
	Percentage of the science and technology allocation in the national budget	4.9	4.9	4.8	4.8	3.9
France	Fr. million	63,330	64,655	71,767	75,008	80,354
	¥100 million	15,408	15,556	15,437	16,217	21,366
	Percentage of the science and technology allocation in the national budget	6.1	6.2	6.6	6.5	6.6
United Kingdom	£ str. million	4,585	4,541	4,662	5,034	---
	¥100 million	11,335	10,767	10,643	11,387	---
	Percentage of the science and technology allocation in the national budget	3.3	3.1	3.0	3.0	---

Note: 1. The accounting procedures for national budgets and for science and technology allocations from national budgets vary from country to country.
2. The amounts for Germany represent the federal budget and do not include the majority of expenditures for research at universities which are shouldered by state governments.

Source: Japan - The Budget Book
United States - Budget of the U S Government
Germany - Faktenbericht 1990 zum Bundesbericht Forschung, 1988;
Finanzbericht; Statistische Informationen;
France - attachments to the draft budget
United Kingdom - Annual Review of Government Funded R&D 1989,1990; The Government Expenditure Plans 1988-1989 to 1990-1991, 1989-1990 to 1991-1992

3.3. Promotion of Research Activities

3.3.1. Promotion of Important Areas of Research and Development

3.3.1.1. Basic and Leading Science and Technology Fields

3.3.1.1.1. Materials Science and Technology

The discovery of new materials has always strongly influenced societies and their economies. Such materials open the door to new fields in technology that substantially alter existing ones, precipitating changes in the manufacturing sector and in society as a whole. A recent example of such a force for change is the discovery of new superconductive materials.

The exploration of many potential R&D fields in advanced disciplines, such as information/electronics science and technology and life sciences, awaits the development of new advanced materials. The key to advancing this development is R&D in materials science and technology — the common and basic technology that supports the innovative research that lies at the basis of a scientific and technological nation.

Today the need for advanced materials is especially acute in big R&D projects related to supercomputer development, fusion technologies, and space and ocean research and development. The research, development and production of new materials are treated as an immediate priority in the nation's science and technology programs.

3.3.1.1.1.1. Comprehensive Promotion of Materials Science and Technology

Accordingly, the government is currently implementing policies for further advances in many fields of materials science and technology. This is in keeping with the CST's recommendation on priority and also is in conformance with recommendations from the Council for Aeronautics, Electronics and Other Advanced Technologies.

In the Recommendation pursuant to Inquiry No. 11, submitted in November 1984, the CST identified materials science and technology as a basic, leading field with considerable potential for promoting new developments and as one science and technology area aimed at economic activation.

In May 1986 the Prime Minister presented Inquiry No. 14, *Basic Plan for R&D in the Field of Materials Science and Technology,* to the CST for deliberation. The CST began an investigation of R&D objectives and guidelines, submitting its recommendation to the Prime Minister in August 1987. The recommendation was approved by the government in October 1987.

Also, the Council for Aeronautics, Electronics and Other Advanced Technologies established general guidelines for the advancement of materials science and technology through recommendations made in the following three reports.

- Recommendation pursuant to Inquiry No. 5, *General R&D Promotion Policies for Advanced Science and Technology and Associate Materials Science and Technology,* submitted in August 1980
- Recommendation pursuant to Inquiry No. 7, *General R&D Promotion Policies for the Development and Manufacture of New Materials Based on Theories of Materials Design,* submitted in September 1984
- Recommendation pursuant to Inquiry No. 9, *Important Issues and Guidelines for the Promotion of Improved Measurement and Control Technologies Related to New Materials Development,* submitted in March 1986
- Recommendation pursuant to Inquiry No. 13, *Promotion of Comprehensive Research and Development on the Creation of New Substances and Materials with the Ability to Respond to Environmental Conditions*

Intelligently and Manifest Their Functions, submitted in November 1989.

Furthermore, in March 1991, the Minister of State for Science and Technology made an inquiry to the Council concerning *The Promotion of Comprehensive R&D for Advancement of Analysis and Evaluation Technology in Relation to Materials Development* (Inquiry No. 16). The Council is considering measures to promote comprehensive R&D concerning the advancement of analysis and evaluation technology of new materials.

3.3.1.1.1.2. Promotion of Materials R&D

Due to the demand for materials science and technology, government ministries and agencies are participating in R&D in this area.

The Science and Technology Agency is furthering common and basic research in materials science and technology through the work, for example, at the National Institute for Research in Inorganic Materials and the National Research Institute for Metals. Moreover the Agency supports research through the administration of the Special Coordination Funds for Promoting Science and Technology and a number of other programs, including Exploratory Research for Advanced Technology (ERATO), under the auspices of the Research Development Corporation of Japan (JRDC) and the International Frontier Research Program, under the auspices of the Institute of Physical and Chemical Research (RIKEN).

The Ministry of Education also is encouraging basic research in materials science and technology, as well as fostering creativity in the research environment utilizing Grants-in-aid for Scientific Research that allows scientists at national universities to pursue their own chosen avenues of study.

The Ministry of International Trade and Industry is furthering R&D in advanced manufacturing technology under the auspices of the Research and Development Program on Basic Technologies for Future Industries and the Large-scale Industrial Technology Development Program.

3.3.1.1.1.3. R&D in Superconductive Materials

The discovery of high, critical temperature oxide-based superconductors at the IBM Laboratories in Zurich, Switzerland in 1986 captured the attention of the worldwide scientific community. In January 1988, the Science and Technology Agency's National Research Institute for Metals subsequently discovered the first of several bismuth-based superconducting compounds.

Although commercial applications of this family of materials are expected to dramatically affect the world's socioeconomic situation, the current reality is that superconductive materials are still far from being commercially useful. Basic and innovative R&D is needed in areas such as the theoretical description of high critical temperature superconducting behavior and in new materials research.

To this end, a number of government ministries and agencies are promoting R&D into superconductive materials in accordance with *The Basic Measures for Promoting Superconductivity Research and Development* compiled in November 1987 by the Ad-hoc Committee on Superconductivity which was set up under the CST's Policy Committee.

In May 1988, the Science and Technology Agency set up *The Multi-core Research Project on Superconductivity* to promote the fundamental research required to realize the potential of new superconductive materials. This project takes a two-fold approach.

Firstly, it encourages maximum utilization of the R&D potential of research organizations such as the National Research Institute for Metals, the National Institute for Research in Inorganic Materials, the Japan Atomic Energy Research Institute, the Power Reactor and Nuclear Fuel Development Corporation, the National Space Development Agency of Japan, and the Institute of Physical and Chemical Research (RIKEN).

Secondly, it encourages joint research projects between Japanese and overseas scientists and fosters an environment that promotes the exchange of scientists and information.

The Ministry of Education is promoting basic research in superconductors utilizing Grant-in-aid for Scientific Research for innovative programs to researchers at the national universities.

The Ministry of International Trade and Industry also is promoting joint projects to develop superconductive materials by promoting industrial-academic-government cooperation. The Ministry's work is mainly carried out as part of the Moonlight Project and the Research and Development Program on Basic Technologies for Future Industries, utilizing research institutes such as the Electrotechnical Laboratory and the National Chemical Laboratory for Industry as key institutes for cooperation. The Ministry also is providing support for the International Superconductivity Technology Center (ISTEC).

The Ministry of Posts and Telecommunications is pursuing R&D on superconductor technology for advanced telecommunications systems. This research is being carried out under the auspices of *The R&D on High-speed and High-performance Communications Technology by using High-temperature Superconductors* as a part of the Frontier Research and Development for Next-generation Telecommunications Systems Program which is being promoted through industrial-academic-government cooperation centering on its Communications Research Laboratory.

Finally, the Ministry of Transport is supporting the R&D of a magnetic-levitation railway system using superconductors. This research is being funded by subsidies provided to the Railway Technical Research Institute (RTRI).

3.3.1.1.1.4. Promotion of International Cooperation in Material Science and Technology

The government is supporting a number of bilateral and multilateral research projects and is encouraging the flow of information and interaction between researchers. Some of these projects are described below.

(1) Bilateral projects

- Studies of High-Strength/High-Conductive Materials and Their Application to High-Field Magnets, between the National Research Institute for Metals (Japan) and the Francis Bitter National Magnet Laboratory (the National Science Foundation, the United States). This project was adopted in May 1990 under the Japan-U.S. Science and Technology Cooperation Agreement.
- Atom Arrangement Design and Control for New Materials, between the Research Development Corporation of Japan and Cambridge and London Universities in the United Kingdom.

(2) Multilateral projects

- The Versailles Project on Advanced Materials and Standards (VAMAS)
- The Information Exchange Task Force on Superconductive Power Applications of the International Energy Agency (IEA)

Further, in 1990, Japan became the selected country for the International Electrotechnical Standard Commission's (IEC) recently established Technical Committee on Superconductivity (TC-90).

3.3.1.1.2. Information/electronics Science and Technology

3.3.1.1.2.1. Importance of Promotion

In recent years Japan has made remarkable progress in information and electronics science and technology. In addition to the development of hardware technologies such as large-scale ultrahigh-speed and ultrahigh-integrated circuits, opto-electronics technology of optical devices, etc. and the production of more compact and higher-speed computers, the development of software technologies has been promoted, and

the entire field has been placed in a central position in the development of leading technologies.

Since the application areas of information and electronics science and technology range widely from various industrial sectors to household and individual life, effects of R&D in this area on industry, technologies and social life in the country are immeasurable. Furthermore, the harmonious development between science and technology and mankind and social life will be increasingly important in the future and R&D activities capable of contributing to such progress are desired strongly.

3.3.1.1.2.2. Important R&D Tasks

(1) Devices, etc.

Microelectronics R&D of high-speed logic devices and large-capacity memory devices are prerequisites for continued advancement in high-speed image processing and high-speed, wide-bandwidth data transmission, as well as in user interface technology and in the processing, transfer and storage of information.

A medium- to long-term analysis suggests that physical and chemical research and application-oriented engineering R&D in the following fields also merits serious attention.

- Quantum behavior of electrons
- Properties of materials that have undergone atomic lattice manipulation or alteration
- Micro-functional properties of biological structures

Practical research activities are being conducted in *The Creation of Materials for High-functional Opto-electronic Devices with a Liquid-drop Epitaxy Method* by the National Research Institute for Metals of the Science and Technology Agency and *"Development of Quantized Functional Devices"* through the R&D Program on Basic Technologies for Future Industries by the Ministry of International Trade and Industry.

(2) Information Processing

Trends in information processing technology promise not only quantitative improvements such as higher speeds and increased capacity, but also qualitative improvements such as interpretation of information at a conceptual level and inference, learning and judgement by the function itself. Continued progress in this area urgently requires closely coordinated R&D in both hardware and software, including new conceptualizations of algorithms, program language and architectures.

One of the projects currently underway is the research on basic and fundamental technologies relating to massively parallel computing systems, necessary for greatly-increased processing speeds.

Another important R&D field is the research on basic and fundamental technologies of neural network models and fuzzy logic systems that are essential in achieving capabilities such as understanding of imprecise expressions and knowledge, inductive reasoning, analogistic processing and learning. To this end, research on *Fuzzy Logic Systems and Their Applicability to User Interfaces and Non-linear Logic-based Systems* and research on *The Development of Fundamental Technology for Sensor Fusion* are being conducted with funding allocated from the Special Coordination Funds for Promoting Science and Technology.

In the Ministry of International Trade and Industry, the R&D of the 5th-generation Computers is being conducted. In addition, the development of Structurized Models of New Software is being performed through the R&D Program on Basic Technologies for Future Industries; Research on an Information Processing System with a Flexible Structure is underway in the Electrotechnical Laboratory.

(3) Human Interfaces

Information systems are processing increasingly large volumes of information that is being accessed by more and more users. To meet user

demands, the equipment used in information systems no longer can be confined simply to mechanical processing, but must be able to function with human-like intelligence. Research in the psychological and cognitive sciences will help identify methods for effective man-machine interaction.

In the Communications Research Laboratory of the Ministry of Posts and Telecommunications, *The R&D Program on Network Human Interfaces* is being carried out as a part of the Research for Next-generation Telecommunications Systems Program. In the Ministry of International Trade and Industry, *The Development of Fundamental Technologies for the Dispersed Information Processing Environment of the Future* is being promoted.

(4) Information transmission

The information-oriented structuring of society has increased the dependence on telecommunications, necessitating research in high-speed, high-volume and more advanced telecommunications systems that support more sophisticated applications.

In cable-based telecommunications, coherent-lightwave optical communication systems using lasers have the potential to realize long-distance data transmissions with an exceptionally high volume.

In wireless-based telecommunications, R&D is underway on high-frequency oscillators and the other devices, including components, peripheral circuits, antennas and modulators/demodulators, used for transmission over bandwidths ranging from millimeter to ultraviolet wavelengths.

Research also is being carried out on telecommunications technologies based on new principles, such as nonlinear optical phenomena, to cope with the increasing high-speed and high-volume communications of the future.

The Ministry of Posts and Telecommunications has initiated *R&D of Basic Technology for Ultra-multidimensional, Plastic Networks* as a part of the Research for Next-generation Telecommunications Systems Program -- to investigate promising areas in advanced telecommunications, including dynamic networks that can be freely configured or reconfigured to many different connection topologies and intelligent networks able to provide services for high-level applications.

Also, in the Ministry of International Trade and Industry, *R&D of a Database System with Mutually Operating Computers* is being conducted to construct a dispersed database system highly reliable in response to multi-media demands.

(5) Application to Social Needs

R&D is underway for the implementation of applications based on the technologies outlined in the previous sections. This work is focused on the advancement of society and the enrichment of individual lifestyles through effectively applying these technologies in support of daily life, medical care, education, production and cultural pursuits.

Table 3-3-1 summarizes the major R&D subjects in information/electronics science and technology undertaken by the various government ministries and agencies during FY1991.

3.3.1.1.3. Life Sciences

Research in the life sciences aims at elucidating the complex and elaborate mechanisms in living organisms. The life sciences have the potential to contribute substantially to the solution of many problems related to health care, medical treatment, environmental protection, agriculture, forestry, fishery and chemical industries.

3.3.1.1.3.1. Basic Policies for the Promotion of Research in the Life Sciences

In 1971 the CST submitted its Recommendation pursuant to Inquiry No. 5, citing the importance of promoting research in the life

Table 3-3-1. Major research subjects in information / electronics science and Technology (in FY1991)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	* Special Coordination Funds for Promoting Science and Technology	* Research to develop the fundamental technology of sensor fusion * Research to construct self-organization-type information base systems to support creative R&D activities * Research concerning fuzzy systems and their applications to human and natural systems * Research concerning generation of vacuum ultraviolet rays and the technology of their use
	* National Research Institute for Metals	* Creation of materials for high-functional opto-electronic devices by liquid-drop epitaxy method
	* National Institute for Research in Inorganic Materials	* Research concerning CBN opto-electronic materials
	* Institute of Physical and Chemical Research	* Research on photodynamics * Research on frontier materials
	* Research Development Corporation of Japan	* Research into quantized magnetic flux analysis, phase analysis, terahertz frequency characteristics, and quantum wave theory
	* Japan Information Center of Science and Technology	* Development of databases for frontier materials
Environmental Agency	* National Institute for Environmental Studies	* Construction of databases for research of the earth's environment
Ministry of Education	* National universities (through provision of grants-in-aid for scientific research and other funding)	* Optical properties of quantum wells under electric fields and their application to ultrahigh-speed optical devices * Advancement of man-machine interfaces by using voice language
Ministry of International Trade and Industry	* Large-scale Industrial Technology Research and Development Program	* Database systems for intercomputer communication * Measurement and application technology of human senses
	* R&D Program on Basic Technologies for Future Industries	* Quantized functional devices * Models for structurizing new software * Bio-devices
	* Development of Basic Computer Technologies	* Fifth-generation computer R&D
	* Electrotechnical Laboratory	* Research concerning integrated processing of multiphase information * Research concerning new functional structure of electronic devices * Research concerning dialogue systems with natural language * Research concerning information processing schemes with flexible structures

(Tab.3-3-1)

Ministry or agency	Research institute or program	Subject
Ministry of International Trade and Industry	* Products Science Research Institute	* Research concerning configurative operation properties in human interfaces * Research concerning measurement and engineering structure of human skills
	* National Chemical Laboratory for Industry	* Research into the control technology for chemical reactions using lasers
Ministry of Transport	* Electronic Navigation Research Institute	* Research concerning an aircraft collision prevention system having a horizontal evasive function
Ministry of Posts and Telecommunications	* Communications Research Laboratory	* R&D of network human interfaces * R&D of unexplored electromagnetic waves * R&D concerning fundamental technology for ultra-multi-dimensional plastic networks * R&D concerning propagation of overland moving communication in quasi-microwave bands * R&D of light frequency band widths * R&D of a radio-relay system in the stratosphere * R&D concerning electromagnetic environment measurement equipment and measuring methods

sciences. After that, steady promotion of research in life sciences has been proceeding on the basis of recommendations of the CST.

3.3.1.1.3.2. Promotion of Research on Cancer and the Acquired Immune Deficiency Syndrome (AIDS)

Cancer is the leading cause of death in Japan, being one-quarter of all mortalities. The formulation of an appropriate set of policies to promote cancer research was so important that in 1983 the Cabinet Council for Cancer-Counter Measures submitted a *Comprehensive 10-year Strategy for Cancer Control*. Since FY1984, relevant ministries and agencies have promoted cancer R&D in accordance with this strategy.

In 1987, in response to the growing concern over the acquired immune deficiency syndrome (AIDS), the Cabinet Council for AIDS Counter-Measures formulated *The Programs for General Anti-AIDS Policies.* All relevant ministries and agencies are promoting AIDS research along this line.

3.3.1.1.3.3. Promotion of Science and Technology Research on Longevity

Demographic trends in Japan indicate a more rapid aging of the population than that seen in other countries. In recognition of this, the Cabinet approved *The Programs for Adjusting to an Aging Population* in 1986. Relevant ministries and agencies are promoting R&D on longevity in accordance with these programs.

3.3.1.1.3.4. Promotion of Recombinant DNA Research

Experiments in recombinant DNA technology have improved the quality of life by assisting in determining the cause of diseases, manufacturing pharmaceutical compounds, developing micro-organisms for specific applications and breeding new varieties of crops. Another facet of recombinant DNA experiments is their potential to create new or altered life.

The CST responded to a governmental inquiry on the safety of experiments in recombinant DNA in its 1979 Recommendation pursuant to Inquiry No. 8, *Basic Policies for the Promotion of Research in Recombinant DNA*. Based on

this, the Prime Minister enacted *Guidelines on Recombinant DNA Experimentation* the same year and R&D activities were started within this framework. The Guidelines have been amended eight times to reflect increasing knowledge in the field. The CST plans to continue to review the Guidelines to meet the increase of knowledge and requirements in research ensuring safety in the experiments.

In 1978, the Science Council of the Ministry of Education proposed its own set of guidelines to ensure the safe, smooth progress of research on recombinant DNA at the nation's universities and associated institutions. *The Guidelines,* which take into account recommendations from experts in the field, were first published in 1979 and have subsequently undergone seven revisions as a result of further deliberations within the Council.

In considering the use of recombinant DNA technology at the stage of commercialization, the Ministry of Health and Welfare, the Ministry of International Trade and Industry and the Ministry of Agriculture, Forestry and Fisheries have issued guidelines for R&D under their respective jurisdictions.

3.3.1.1.3.5. Promotion of Studies on the Human Genome Analysis

Human genome analysis is aimed at reading out of the base sequences of the entire human DNA. It is expected that the analyses will bring about many benefits such as clarification, diagnosis and treatment of genetic diseases and other illnesses and the elucidation of organisms' alleged evolutionary mechanisms. Based on Recommendation No. 12 by the Council for Aeronautics, Electronics and Other Advanced Technologies in 1988, *Comprehensive Strategy for Promoting R&D on Human Genome Analysis,* and the proposal by the Science Council in 1989, various research activities have been conducted in relevant ministries and agencies. For example, research on the automation of the sequencing system, preparation of analysis materials and research focussing on particular genes have been conducted mainly in the Institute of Physical and Chemical Research and in universities. In 1990, the CST set up of the Human Genome Committee in its Panel on Life Sciences. The Committee has been examining the present status in this country, international trends and the future course of human genome analysis. The Ministry of Agriculture, Forestry and Fisheries has started research on rice genome analysis in 1991.

3.3.1.1.3.6 Promotion of Research on Glyco-technology, etc.

Life sciences measures cover an extremely wide-ranging area from the elucidation of life phenomena, industrial use of animals and plants to the problems of population and food. Recently in particular, the Council for Aeronautics, Electronics and Other Advanced Technologies submitted its Recommendation No. 14 *Policy for Promoting General R&D for Basic Studies in Glyco-technology,* in July 1990. Based on the recommendation, research activities have started focussing on the elucidation of functions in the living body and the analysis of structures of sugar-chains with the cooperation and coordination of the Science and Technology Agency, the Ministry of Health and Welfare, the Ministry of Agriculture, Forestry and Fisheries and the Ministry of International Trade and Industry.

Table 3-3-2 summarizes the major R&D subjects undertaken by the various government ministries and agencies during FY1991.

3.3.1.1.4. Soft Science and Technology

The CST's Recommendation pursuant to Inquiry No. 11 submitted in November 1984, and *The General Guideline for Science and Technology Policy* approved by the Cabinet in March 1986, both stress the need for promoting scientific methodology in so-called soft science and technology.

Table 3-3-2. Major research subjects in life sciences (in FY1991)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	* Special Coordination Funds for Promoting Science and Technology	* Research on the development of basic technology to elucidate the immune system * Development of the basic technology to analyze the mechanisms of cancer invasion and metastasis * Development of fundamental techniques for human gene mapping * Development of highly-sensitive, high resolution non-destructive techniques to elucidate the biological functions of living systems at the molecular level * Research on fundamental technology for structural and functional analysis of glycochains
	* Institute of Physical and Chemical Research	* Special research on biological functions of living organisms, including a study on their genetic composition * Bio-homeostasis research program, research program on brain mechanisms of mind and behavior, and photodynamics research program through the frontier research program * Promotion of recombinant DNA experimentation * Gene bank projects
	* Research Development Corporation of Japan	* Exploratory Research for Advanced Technology (Biophoton Pro., Morpho Genes Pro., Plant Econochemicals Pro., Genosphere Pro., etc.) * Cooperative Development of New Technology (Develop techniques to produce specific antibodies using the immune system of birds and other creatures)
	* National Institute of Radiological Sciences	* Application of heavy ion beams to the medical field
	* Japan Atomic Energy Research Institute	* Research into the utilization of radioactivity for biotechnology
Environment Agency	* National Institute for Environmental Studies	* Research to elucidate the chemical environments of advanced technologies * Research concerning effective use and environmental assessment of biotechnology for preservation of the environment
Ministry of Finance	* Research Institute of Brewing	* Research concerning structure and functions of organic cells involved in brewing and distillation
Ministry of Education	* National universities (through provision of grants-in-aid for scientific research and other funding)	* Overview of special studies on cancers * Complete features of the *E. coli* genome * General basic research on AIDS * Molecular cytobiological research into the mechanisms of aging in the brain * Molecular cytobiological research into the mechanisms of reproduction in higher plants

(Tab.3-3-2)

Ministry or agency	Research institute or program	Subject
Ministry of Health and Welfare	* Institute of Public Health	* Research concerning physiological reactions and their effects on health at the time of radical changes in environmental temperatures and load of cold
	* National Institute of Health	* Genetic biochemical and molecular-biological research concerning action orders of physio-active substances * Cell-biological and molecular-biological research concerning infection and the outbreak of diseases of microorganisms
	* National Institute of Health Nutrition	* Motor and vegetative physiological research of physical indications in health strengthening
	* National Institute of Leprosy Research	* Analytical research on specificity, structure and function of protein produced by leprosy bacillus
	* National Institute of Hygienic Sciences	* Research to evaluate the significance of indicators for biological reactions * Basic research concerning optical isomers aiming at proper evaluation of medicines
Ministry of Agriculture, Forestry and Fisheries	* National Institute of Agrobiological Resources * National Institute of Agro-Environmental Sciences * National Institute of Animal Industry * National Grassland Research Institute * Fruit Tree Research Station * National Research Institute of Vegetables, Ornamental Plants and Tea * National Institute of Sericultural and Entomological Science * National Institute of Animal Health * National Foods Research Institute * Forestry and Forest Products Research Institute * Regional Fisheries Research Laboratories	* Analytical research on rice genome and comprehensive research concerning biotechnological breeding of plants * General research in biotechnological plant breeding * General research to develop new agricultural, forestry and fishery techniques through the clarification and control of biological information * General research to elucidate the ecological order in the agricultural, forestry and fishery systems and develop optimal controls * Preparation of a generalized system for the control and utilization of agricultural, forestry and fishery gene sources and genetic breeding information * Development of quality- and productivity-increasing technology of wheat and other crops from dry fields which were formerly paddy fields * Comprehensive research to develop high-functional materials through structural changes of sugar

Soft science and technology can be used to apply a scientific approach to the understanding of thought and activity patterns--sometimes called humanware--based on the characteristically human attributes of emotion and creativity. R&D in soft science and technology can provide much needed information on the working mechanisms of brain-related activities such as cognition, thought, inference and judgment. They can then be used to develop technology to assist or partially substitute for these hitherto exclusively human functions. Artificial intelligence is one example of an active field of R&D in soft science and technology.

The CST considers that soft science and technology have great potential to further the

(Tab.3-3-2)

Ministry or agency	Research institute or program	Subject
Ministry of International Trade and Industry	* National Chemical Laboratory for Industry	* Research concerning synthesis of physio-active organic metal compounds
	* Government Industrial Research Institute, Nagoya	* Research concerning bio-reactors moving under high temperatures by using heat-resistant enzymes
	* Fermentation Research Institute	* Development of biological catalysts through oxidation reaction of micro-water systems * Research into synthesized location-selective bioreactors
	* Research Institute for Polymers and Textiles, Governmental Industrial Research Institute, Osaka and Industrial Products Research Institute	* Research concerning complex molecular systems having sensing capability
	* Industrial Products Research Institute	* Research concerning measurement and engineering structure of human skills
Ministry of Posts and Telecommunications	* Communications Research Laboratory	* R&D of high-efficiency coding technology through models of perception mechanisms
Ministry of Construction	* Public Works Research Institute	* Research concerning actual use of sophisticated treatment processes using fixation microorganisms

development of the role for science and technology in the advancement of society and the enrichment of individual lifestyles. Accordingly, in FY 1987 and 1988 the CST allocated funding from the Special Coordination Funds for Promoting Science and Technology to sponsor a two-year *Investigation of the Present State of and Future Methods for the Advancement of R&D in Soft Science and Technology.* The result of this study gave the CST a better grasp on the current state of R&D and the current fields in which soft science and technology are being applied.

In 1974, the National Institute for Research Advancement (NIRA) was established with investments from national and local government organizations and private corporations. NIRA has carried out research to ensure the effective coordination of general R&D in soft science and technology. This organization also ensures the optimal application of research results.

The National Institute of Science and Technology Policy (NISTEP), established by STA in July 1988, and other government policy research organizations currently are enhancing their policy research, which is one kind of soft science and technology, to clarify many problems under government jurisdiction in this area, especially those which have become more complex as a result of the internationalization of the nation's society and economy.

3.3.1.1.5. Space/aeronautical Science and Technology

3.3.1.1.5.1. Space Development

Space development plays an important role in furthering science and technology and improving the quality of people's lives through its contributions in areas such as scientific observation, communications, broadcasting and meteorological observation.

Japan's space development has been conducted under the cooperation of organizations including the National Space Development Agency of Japan and the Institute of Space and Astronautical Sciences. Activities are based on

both the "Fundamental Policy of Japan's Space Development" (published in March 1978, revised in June 1990) and the "Space Development Program," which specifies the annual development plans in accordance with the Fundamental Policy, as prescribed by the Space Activities Commission.

In this Fundamental Policy, the following three directions are pointed out as basic principles for Japan's space development policy.

- Response to advancing and diversifying needs
- Consistency with Japan's role in international society to improve the nation's capability to continuously and freely conduct various space activities and international cooperation
- Encouragement of the private sector in the space development

The following are the principal objectives of this Policy.

- Promote scientific research
- Establish satellite and launch vehicle technology
- Form the foundation for utilizing space environment
- Form the foundation for manned space activities

(1) Satellites

Since the successful launch of Japan's first satellite, *Ohsumi,* in 1970, Japan has successfully launched 46 satellites by April 1991, and ranks third following the United States and the U.S.S.R.

The following sections describe the main satellites. Table 3-3-3 provides a full listing of satellites and payloads launched during FY1990, and those planned to be launched in FY1991 and thereafter.

① Scientific Field

The Institute of Space and Astronautical Sciences, in cooperation with universities and related organizations nationwide, has successfully launched 19 scientific satellites. These include the 11th Scientific Satellite ASTRO-C for observing X-ray sources at the center core of the active galaxy, the 12th Scientific Satellite EXOS-D for precise observation of the acceleration mechanism of the plasma particles responsible for the Aurora in the earth's magnetic field, and the 13th Scientific Satellite MUSES-A to performed the experimental lunar swing-by technique accompanied by precise orbit determination for future planetary exploration.

Other scientific satellites currently under development include the following.

1) The 14th scientific satellite SOLAR-A will investigate high-resolution imaging of solar flares during the solar maximum period. This is a cooperative Japan-U.S. project.
2) The magnetosphere observation satellite GEOTAIL, a collaborative program with NASA, is intended to observe the structure and dynamic of the extended tail of the magnetic field line on the night-side of the Earth.
3) The 15th scientific satellite ASTRO-D will investigate X-ray precision imaging and spectrum observation of heavenly bodies at the far-edge of space.
4) The 16th scientific satellite MUSES-B is designated to investigate the deployment of a large dexterous structure and to test the phase stable reference transfer by radio waves for Space VLBI.
5) The 17th scientific satellite LUNAR-A is being designed to elucidate the intra-lunar crustal and thermal structure.

② Earth and Meteorological Observation

Regarding *The Himawari* series of geostationary meteorological satellites, GMS-4 (Himawari 4), launched on September 6, 1989, is currently operational. GMS-5 is currently under development.

The *Momo* series of marine observation satellites are used to observe the color and temperature of the ocean surface and other ocean phenomena. MOS-1 (*Momo* 1) and MOS-1b (*Momo* 1b), the latter launched on February 7, 1990, are presently in service. Other satellites

Table 3-3-3. Satellites and payloads launched during FY1990 and planned for FY1991 and thereafter

Satellite/payload	Weight (kg)	Orbit	Orbital altitude (km)/ location	Launch vehicle	Launch date (fiscal year)	Major objectives
* *FY*1990						
BS-3a broadcasting satellite	Approx. 550	Geostation-ary orbit	110°E	H-I	August 28, 1990	* Continuation of the broadcast services provided by the BS-2 satellite * Service capacity for the ever-increasing volume and diversity of broadcasting * Development of broadcast satellite technology
* Satellites and payloads to be launched during *FY*1991 and after (as of April, 1991)						
BS-3b broadcasting satellite	Approx. 550	Geostation-ary orbit	110°E	H-I	1991	* Continuation of the broadcast services provided by the BS-2 satellite * Service capacity for the ever-increasing volume and diversity of broadcasting * Development of broadcast satellite technology
SEPAC space experiment with particle accelerators	-	-	-	U.S. Space Shuttle	1992	* Elucidation of the light-emitting mechanism of auroras, the movement of an electrically charged particle in plasma, and the promotion of the radio wave
SOLAR-A 14th scientific satellite	Approx. 420	Approxi-mate circular orbit	Approx. 550 to 600	M-3SII	1991	* Joint Japan-US observation project to investigate high-resolution imaging of solar flares during the solar maximum period
ERS-1 earth resources satellite 1	Approx. 1,400	Sun synchronous subrecurrent orbit	Approx. 570	H-I	1991	* Natural resource and national land surveys * Surveys of agricultural, forestry and fishery resources * Environmental safety, disaster prevention and coastal safety monitoring * Further development of active observation technology
FMPT first material processing test *Fuwatto* '92	-	-	-	U.S. Space Shuttle	1992	* Characteristics of materials experimentation in space environment by a Japanese scientist aboard the Space Shuttle
GEOTAIL magnetosphere observation satellite	Approx. 750	Equatorial orbit	50,000 to 1.6 million	U.S. launch vehicle	1992	* Observation research by Japan-U.S. cooperation of the structure and dynamics of the extended tail of the magnetosphere on the night-side of the Earth
ASTRO-D 15th scientific satellite	Approx. 430	Approxi-mate circular orbit	Approx. 500 to 600	M-3SII	1992	* Investigation of X-ray precision imaging and spectrum observation of heavenly bodies at the far-edge of space
ETS-VI engineering test satellite-VI	Approx. 2,000	Geostation-ary orbit	-	H-II	1993	* Confirmation of H-II test rocket performance * Further development of large-scale geostationary 3-axis satellite bus technology required for the development of satellites in the 1990s * Development of technology and testing of high-performance satellite communications systems

(Tab.3-3-3)

Satellite/payload	Weight (kg)	Orbit	Orbital altitude (km)/ location	Launch vehicle	Launch date (fiscal year)	Major objectives
SFU space flyer unit	Approx. 4,000	Circular orbit	Approx. 300 to 500	H-II	1993	* Various scientific and engineering experiments * Astronomical observations * Acquiring the opportunity required for the R&D of advanced industrial technologies * Reliability testing and improvement of exposed facility of JEM common experiment equipment
GMS-5 geostationary meteorological satellite-5	Approx. 340	Geostationary orbit	-	H-II	1993	* Improvement of weather observation * Development of meteorological satellite technology
MUSES-B 16th scientific satellite	Approx. 700	Extended elliptical orbit	1,000 to 20,000	M-V	1994	* Research into the mechanism of large-scale parabolic antenna deployment * Research into the communications technologies required for VLBI
LUNAR-A 17th scientific satellite	Approx. 585	Circular orbit	100km over the moon surface	M-V	1995	* Elucidation of crustal structure and thermal structure of the moon
ADEOS advanced earth observing satellite	Approx. 3,500	Sun synchronous sub-recurrent orbit	Approx. 800	H-II	1994	* International cooperation in monitoring global environmental changes * Development of the technology which will be required by the next generation of earth observation platforms and similar satellites * Development of the technology required for the relaying earth observation data
COMETS communications and broadcasting engineering test satellite	Approx. 2,000	Geostationary orbit	-	H-II	1996	* New technologies of sophisticated moving-body satellite communications technology, inter-satellites communications technology and sophisticated satellite-broadcasting technology in the communications and broadcasting areas, multi-frequency bandwidth integration technology and efficiency-increasing technology of large-scale stationary satellites will be developed, experimented with and demonstrated.
JEM Japanese experimental module (attachable) for Space Station Project	Undecid -ed	-	400	U.S. Space Shuttle	1998	* Experimentation in materials testing, the life sciences, general science, earth observation and communications

currently under development are the followings.

1) The earth resources satellite ERS-1 intends to further establish active observation technology and perform observations for natural resource surveying, national land surveys and surveys for the management of agriculture, forestry and fishery resources.
2) The advanced earth observing satellite ADEOS intends to monitor global environmental changes and to further promote international cooperation in the field of earth observation.

③ Communications and Broadcasting

Regarding *The Sakura* series of communications satellites, CS-3a (*Sakura* 3a) and CS-3b (*Sakura* 3b) are currently operational.

The first broadcasting satellites were *The Yuri* series, of which BS-2b (*Yuri* 2b) is currently operational. This series is being taken over by the 3 series of broadcasting satellites, of which the BS-3a (*Yuri* 3a) broadcasting satellite was launched on August 28, 1990. Other satellites currently under development are the followings.

1) Broadcasting satellite BS-3b is scheduled for launch in FY1991.
2) The development of the communications and broadcasting engineering test satellite (COMETS) is proceeding with the purpose to develop, experiment with, and demonstrate advanced mobile satellite communications technology, inter-satellite communications technology, high-performance satellite broadcasting technology and other new technologies in the communications and broadcasting area as well as multiple frequency-band integration technology and technology for higher-performance large-scale geostationary satellites.

④ General Satellite Technology

The Kiku series of engineering test satellites are used to test common technologies of variety types of satellites. The engineering test satellite ETS-V (*Kiku* 5), designed to test mobile communications technology, is currently in operation. ETS-VI is under development; it will be used for further R&D issues of large scale three-axis stabilized geostationary satellite bus technology, and also for development and testing of advanced technologies for fixed and mobile communications and intersatellite communications.

(2) Launch Vehicles

For launching scientific satellites, the M (mu) series rockets have been developed, succeeding the L (lambda) series rockets. M series launch vehicles use solid propellents, for all stages. Currently the M-3SII is being used. However, development of the three-stage M-V launch vehicle, with enlargement of each stage and a simpler configuration, is underway to meet the requirements of scientific observation missions after the 1990s.

Regarding launch vehicles for geostationary satellites, after development of N series rockets, H series rockets are under development and in use. The three-stage H-I launch vehicle, which can launch a 550 kg payload into geostationary orbit, is currently in use. Its second stage engine uses a liquid-hydrogen/oxygen propellant. The H-II launch vehicle is a large two-stage vehicle being developed to launch two-ton class geostationary satellites to meet the satellite demand of the 1990s. This launch vehicle uses liquid-hydrogen/oxygen engines in both stages. The first test launch of the H-II is planned for FY1992 (Table 3-3-4).

(3) Space Utilization and Manned Space Activities

① First material processing test (*Fuwatto* '92)

Fuwatto '92 is a seven-day manned mission scheduled for FY1992 in which a Japanese scientist will conduct material science experiments in the space environment aboard the U.S. Space Shuttle. This mission will provide an important opportunity to acquire technology needed for manned space flights.

② Space Station Project

The Space Station Project is a multilateral program involving Japan, the United States, some European countries and Canada, with the goal of constructing a manned space station in a low (approx. 400 km) earth orbit. The space station will establish the infrastructure for utilizing the space environment and for furthering manned space activities.

Table 3-3-4. Main specifications of vehicles used to launch satellites

Launch vehicle type	Stages	Overall length (m)	Diameter (m)	Gross weight (tons)	Propellant
M-3SII	3	27.8	1.41	62.0	Solid for all stages
M-V	3	About 30	About 2.5	About 128	Solid for all stages
N-II	2	35.4	2.44	133.4	1st and 2nd stages, liquid; SOB, solid
	3	35.4	2.44	134.7	1st and 2nd stages, liquid; 3rd stage and SOB, solid
H-I	2	40.3	2.44	138.7	1st stage, liquid; 2nd stage, liquid oxygen/hydrogen; SOB, solid
	3	40.3	2.44	139.2	1st stage, liquid; 2nd stage, liquid oxygen/hydrogen;3rd stage and SOB, solid
H-II	2	About 50	About 4	About 264	1st and 2nd stages, liquid oxygen/hydrogen; SRB, solid

Japan will be participating in the project through the Japanese-developed JEM, (Japanese Experimental Module), and Japanese astronauts will remain on board for a long period. In September 1989, Japan deposited the Inter Governmental Agreement that defines the program's framework and has just started participating in the activities of the development phase.

③ Others

Japan is committed to a number of other activities aimed at utilizing the space environment and at acquiring the technology for manned space activities. These include the following.

1) Development of the SFU (space flyer unit)

The SFU is reusable vehicle that will fly in a low earth orbit for several months at a time, followed by reentry and recovery. The SFU will ensure that Japan maintains an opportunity for space experiments.

2) Japanese participation in First and Second International Microgravity Laboratories (IML-1 and IML-2) that will be performed on board the U.S. space shuttles.

Work carried out under these projects will enable Japan to accumulate the technology required for the Space Station Project and to acquire technologies for space utilization and manned space activities.

(4) Fundamental and Advanced Research on Satellite and Launch Vehicle Technology

The National Aerospace Laboratory and research institutes of related ministries and agencies are conducting fundamental research on launch vehicle and satellite technology. The laboratories and research institutes also are working in a number of advanced research areas, including an H-II orbiting plane (HOPE), an unmanned winged reusable space vehicle which can be used to transport cargo to the Space Station and a manned space-plane.

3.3.1.1.5.2. Aeronautical Technology

R&D in aeronautical technology is

knowledge-intensive and makes use of state-of-the-art technologies from a wide range of disciplines. As a result, developments in this field can promote advancements over a wide range of downstream technologies, in addition to the basic goal of improving the equipment and infrastructure for air transportation.

Given its technologically strategic nature, extensive R&D in aeronautics is critical to the overall promotion of science and technology and to the development of a technologically-oriented society.

The current state of the nation's aeronautical technology is the direct result of knowledge acquired through R&D on the Japanese-developed YS-11 commercial transport airplane, the international joint development of the Boeing 767 passenger jet and other aircraft. This technology is now at the stage where Japanese private sector corporations are participating or intending to participate in a number of domestic and international aircraft development projects, some of which are listed below.

- The design and manufacture of the 350-seat twin-engine Boeing 777 passenger jet
- The design and manufacture of the 150-seat YXX passenger aircraft
- Investigation of the development of a next-generation supersonic commercial transport airplane
- Development of the V2500 jet engine with aeroengine companies in the United States, the United Kingdom, Germany and Italy

To promote actively the development of aircraft and their engines, it is necessary to enhance futuristic technological levels. To this end, the government is formulating measures designed to encourage R&D in this field in accordance with recommendations contained in reports prepared by the Council for Aeronautics, Electronics and Other Advanced Technologies.

In its Recommendation pursuant to Inquiry No. 8, *Important Issues and Practical Promotional Measures for R&D on Energy-Efficient Aircraft,* submitted in August 1986, the Council made a number of proposals to the government regarding R&D on innovative aeronautical technologies aiming at the 21st century. In March 1991 the Council made its final report on *The Examination of Practical Plans for R&D of Fan-Jet STOL Aircraft* (Inquiry No.1).

Within this framework, the Science and Technology Agency's National Aerospace Laboratory is promoting aeronautic R&D with the goal of establishing the technologies required for such futuristic aeronautics R&D. Since FY1987, the Laboratory has encouraged research on aerodynamics technology, the technology of new composite material structures, flight control technology, propulsion technology and other state-of-the-art aeronautical transportation technologies that will be required for future aircraft such as hypersonic transport planes, space planes and highly efficient, large payload transport airplanes.

The Laboratory also is furthering R&D on short take-off and land (STOL) aircraft powered by fanjet engines, focussing on the development of computer databases for the practical application of test flight data using the test plane Asuka.

The Laboratory is encouraging research on basic technologies such as numerical simulations and also is setting up test facilities for composite material structures, wind tunnels and other test and research facilities which are available to appropriate aeronautics R&D organizations.

In addition to the Science and Technology Agency, a number of other ministries also are engaged in aeronautical R&D.

The Ministry of Transport's Electronic Navigation Research Institute is conducting R&D on navigation and air-traffic control systems to improve air safety. Findings from this research will ensure steady development of the air transportation system.

The Ministry of International Trade and Industry is furthering R&D of propulsion

systems for future high-reliability supersonic transport planes capable of operating at low air speeds through Mach 5. European and American engine manufacturers are participating in this R&D.

3.3.1.1.6. Ocean Science and Technology

Varied marine life, untapped mineral resources, large scale and abundant energy sources make ocean development a promising area.

Because the ocean plays an important role in global change and the crustal dynamics of the earth greatly influence earthquake and volcanos, it is urgent that mechanisms in and around the ocean be elucidated.

Under these circumstances, plans for ocean research and establishment of global-scale ocean observing systems are being promoted in the 1990s.

Promotion of ocean science and technology is indispensable for ocean development and clarifying various ocean phenomena which are not yet well known.

3.3.1.1.6.1. Basic Guidelines for the Promotion of Ocean Science and Technology

The Council for Ocean Development is an advisory committee to the Prime Minister which decides basic and general concepts related to ocean development. The Council's Recommendation pursuant to the Prime Minister's Inquiry on *Basic Concepts and Promotional Guidelines for Long-term Ocean Development,* submitted in May 1990, identifies the following basic principles guiding the advancement of ocean science and technology.

- The promotion of oceanographic studies and development of technologies for the elucidation of global change and ocean phenomena.
- The promotion of science and technology which is useful for overcoming severe oceanic conditions and for creating new ways of ocean development

Related government ministries and agencies are engaged in promoting R&D in ocean science and technology under their respective jurisdictions in accordance with the guidelines of the Council's recommendation. Further, the various ministries and agencies coordinate closely to ensure comprehensive promotion by following the Promotion Program for Ocean Development compiled annually by the Liaison Council for Ocean Development-related Ministries and Agencies.

3.3.1.1.6.2. Promoting R&D in Ocean Science and Technology

For bolstering ocean science and technology, the Science and Technology Agency is promoting pioneering and fundamental R&D, mainly by the Japan Marine Science and Technology Center (JAMSTEC) and also by comprehensive projects with the cooperation of ministries and agencies concerned.

JAMSTEC is developing submersible vessels to provide information in areas related to exploration of the ocean floor, prediction of seismic activity, studies on deep-sea microorganisms, and so on. In 1990, JAMSTEC promoted deep-sea investigations and research activities with the manned research submersible SHINKAI 2000 and the unmanned explorer DOLPHIN 3K, made experimental dives of the SHINKAI 6500, and began development of an unmanned explorer which can dive to 10,000m.

In ocean observations for clarifying ocean phenomena, JAMSTEC conducted R&D using shipboard ocean lidar technology to assess the distribution of plankton in the ocean surface layer and using ocean acoustic tomography technology for three-dimensional observations of ocean temperature, current field and water density over a 1,000 square km area.

Furthermore, JAMSTEC is carrying out the following programs to contribute to the development and exploitation of offshore areas: the New Seatopia Program to establish saturation diving techniques to a depth of 300 m for

Table 3-3-5. Major research subjects in marine science and technology (in FY1991)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	* Special Coordination Funds for Promoting Science and Technology	* Japanese ocean circulation experiment * Research on rift systems in the South Pacific * Japanese Pacific climate study (JAPACS)
	* Research and Development Bureau	* Kuroshio exploitation and utilization research
	* Japan Marine Science and Technology Center	* R&D of a deep-sea research submersible * Research on marine observation and R&D of observation technology * Research and investigations into comprehensive observation of the North Pacific Ocean and Arctic sea areas
Environment Agency	* Research funding to the national research institute engaged in environmental pollution research	* Research concerning nitrogen cycle of deposits in inland bays
	* Water Maintenance Bureau	* Survey to study measures to cope with nutrients such as nitrates and phosphates
	* National Institute for Environmental Studies	* Studies to evaluate the impact of eutrophication on biological life in naturally sheltered coastal bays
National Land Agency		* Surveys for the Promotion of the fisheries in the Amami Islands
Ministry of Education	* National universities and other research institutions	* Ocean Drilling Program (ODP) * Cooperative study of the Western Pacific (WESTPAC)
Ministry of Agriculture, Forestry and Fisheries	* Fisheries Agency	* R&D of the fish breeding industry * R&D of new fisheries technologies * Construction of large-scale high-tech research vessel
	* Japan Marine Fisheries Resource Research Center	* Surveys for the development of unexploited deep-sea fishery resources
Ministry of International Trade and Industry	* Metal mining Agency of Japan	* Surveys for the development of deep-sea bottom mineral resources
	* National Research Institute for Pollution and Resources	* R&D into underwater manganese nodule mining systems
	* Japan National Oil Corporation	* Survey for the R&D of early production testing system
	* New Energy and Industrial Technology Development Organization	* R&D of a seabed oil production system * North Pacific carbon cycle study (NOPACCS)
	* Geological Survey of Japan	* Marine geological study of continental shelves in the eastern margin of the central Japan Sea
Ministry of Transport	* Maritime Technology and Safety Bureau	* Survey and research into small- and medium-sized icebreakers

(Tab.3-3-5)

Ministry or agency	Research institute or program	Subject
Ministry of Transport	* Ports and Harbors Bureau * District Port Construction Bureau	* Development of technology to construct ocean structures
	* Administrative Department, Marine Safety Agency, Marine Safety Research Center	* Research into estimating the time taken by liquid pollutants to degrade in sea water
	* Hydrographic Department, Marine Safety Agency	* WESTPAC
	* Meteorological Research Institute, Meteorological Agency	* Research of oceanic variations through models of ocean circulation
Ministry of Posts and Telecommunications	* Communications Research Laboratory	* R&D of ocean observing aircraft and satellite technology
Ministry of Construction	* River Bureau	* Promotion research of artificial barrier projects
	* Geographical Survey Institute	* Basic research of coastal sea areas

undersea operations; and collaborative projects with local governments to promote the effective utilization of offshore areas at regional and local levels by taking into account the characteristics of each area.

The Science and Technology Agency also organizes joint R&D projects among several related ministries and agencies. These joint R&D projects include the Japan-China joint research program on the Kuroshio to survey the meandering flow of the Kuroshio and its effect on weather and fishing around Japan and East Asia; by allocation of the Special Coordination Funds for Promoting Science and Technology, research concerning atmospheric-oceanic variations and meteorological variations in the Pacific Ocean, research concerning the elucidation of the ocean's general circulation and concerning a comprehensive observation system, and research concerning the elucidation of oceanic plate formation areas (rift system) in the South Pacific Ocean.

The Ministry of Education is conducting ocean-related academic research mainly through the Ocean Research Institute of the University of Tokyo. Programs include research of ocean flux contributing to the clarification of carbon cycles in the ocean, participation in the international deep-sea drilling program (ODP) to collect ocean crust, and the cooperative study of the West Pacific Ocean (WESTPAC).

The Ministry of Agriculture, Forestry and Fisheries, through the Fisheries Agency, is conducting R&D for the promotion of the fish hatchery and fish farming industries.

The Ministry of International Trade and Industry, through the Agency of Natural Resources and Energy and the Geological Survey of Japan, is developing ocean floor ore resources and carrying out geological surveys on the seabed.

The Ministry of Transport is conducting oceanographic observations for hydrographic services through the Maritime Safety Agency and meteorological observations at sea for meteorological operations through the Meteorological Agency.

The Ministry of Construction will conduct a survey promoting artificial barrier operations and the development of creation and preservation

technology of ocean space for coastline operations. Its Geographical Survey Institute is conducting basic surveys of coastal sea areas, etc.

Table 3-3-5 summarizes the main R&D subjects undertaken by the various government ministries and agencies during FY1991.

3.3.1.1.7. Earth Science and Technology

3.3.1.1.7.1. R&D and Related Measures for Understanding Global Phenomena

Sophistication of remote sensing capabilities by satellites, construction of deep-sea submersible survey vessels and similar advances in science and technology have made us aware of naturally occurring global phenomena, such as global warming, depletion of the ozone layer, irregular weather patterns, volcanic and seismic activity and so on. Given that the occurrence of any of these phenomena can have wide-ranging repercussions on mankind, it has become increasingly important to clarify the mechanisms causing these global phenomena.

The prospect of global warming, caused principally by the release of an excess of carbon dioxide into the atmosphere, poses a grave threat to socioeconomic activity on a worldwide scale. Since, however, carbon dioxide is inseparably associated with countless human activities, previously applied solutions — such as the mere restriction of specific substances — are not feasible and wider approaches are needed.

It is natural to promote immediately feasible measures for controlling global warming. Since, however, there remain some global warming problems not yet clarified scientifically at present, it is essential to compile more scientific knowledge so that countermeasures always may be implemented at an appropriate scale. This issue is being discussed in various international meetings including the Intergovernmental Panel on Climate Change (IPCC), and negotiations on the climate change treaty have begun to deal with countermeasures. Japan as a country with advanced science and technology is required to challenge this issue actively and make contributions at an international level.

In Japan, based on the recommendation submitted by the CST, the Prime Minister approved *The Basic Plan for Research and Development on Earth Science and Technology* in August 1990. This plan establishes the various priorities for the promotion of R&D in this field over a ten-year period. It also identifies important R&D issues and indicates the government's role and responsibilities in this area. Another policy statement, *The National Program for Global Environmental Research,* FY1991, was adopted at the Council of Ministers for Global Environmental Conservation in June 1991.

Since problems such as global warming and crustal movement are long term and are not confined to a country, it is of crucial importance to maintain a sense of global partnership and cooperation in R&D in earth science and technology. Accordingly, it is important that Japan play an active role in the World Climate Research Program (WCRP), the International Geosphere-Biosphere Program (IGBP) and other joint research programs and expand joint research projects with research institutions abroad.

Table 3-3-6 summarizes the major research and development subjects in the area of earth science and technology that are currently promoted by related ministries and agencies.

3.3.1.1.7.2. R&D on Earth Observation Technology

R&D on earth observation technology is important to accumulate the information necessary to understand various global phenomena. Japan's two major thrusts in this area are the R&D on earth observation technology, including the R&D on earth observation satellites, and the R&D on marine observation technology such as the development of deep-sea survey vessels.

Table 3-3-6. Major research subjects in earth science and technology (in FY1991)

Ministry or agency	Research institutes, etc.	Subject
Science and Technology Agency	* Special Coordination Funds for Promoting Science and Technology	* Japanese ocean circulation experiment (JOCEX) * Japanese experimental study in the Arctic Area
	* Funds for the Promotion of Surveys and Research in Earth Science and Technologies and Ocean Development	* An observational study of cloud effects for global warming
	* National Research Institute for Earth Science and Disaster Prevention	* A study of disaster predictions in global hydrological processes
Environment Agency	* Funds for the Overall Promotion of Environmental Research	* Research concerning effects of global warming on society and economy * Research concerning elucidation of ozone-layer destruction mechanisms * Structural analysis of ecosystem in tropical forests * Research concerning elucidation of dynamics of acidic rain in East Asia * Research concerning inlet of marine pollutant substances into marine ecosystem
Ministry of Education	* National Research Institute for Polar Regions, Universities, etc.	* General research and observation into the science of the polar regions * Academic research into earthquake and volcanic eruption prediction systems * Academic research into the physical operation of very high altitude atmospheric and meteorological changes * Academic research concerning plate tectonics and materials movement and variations within the earth * Academic research concerning elucidation of processes of physical, chemical and biological interactions controlling entire-global systems
Ministry of Agriculture, Forestry and Fisheries	* Research institutes of the Ministry of Agriculture, Forestry and Fisheries	* Research to develop technology to dynamically elucidate and predict the effect of changes to agricultural, forestry and fishery life forms as the result of environmental change * Development of technology to observe and evaluate agricultural, forestry and fishery resources using remote sensing techniques
Ministry of International Trade and Industry	* Geological Survey of Japan	* Geological, geochemical and geophysical research of active volcanos * Marine-geological research concerning sea areas surrounding the continental shelf in the eastern edge of the central Japan Sea and other subjects
	* R&D on global environment technologies, etc.	* Research on CO_2 fixation technology by artificial photosynthesis and on other subjects

(Tab.3-3-6)

Ministry or agency	Research institutes, etc.	Subject
Ministry of Transport	* Hydrographic Department, Marine Safety Agency	* General ocean surveys of sea areas under agency supervision, oceanographic surveys using earth observation satellites, surveys of ocean floor contours and subterranean structures for earthquake and volcanic eruption prediction, surveys of water temperature, currents and waves in the Western Pacific Ocean as part of the agency's sea lane supervisory activities * Establishment of the Japan Ocean Data Center. Collection, supervision and supply of information on water temperature and the role of currents in ocean water circulation, and materials involved in ocean floor contours, geology and earth-related physics
	* Meteorological Research Institute, Meteorological Agency	* Research concerning elucidation and prediction of mechanisms of meteorological variations including research concerning upgrading of global warming prediction technology * Research on atmospheric and oceanic variations through meteorological satellites * Research of models to forecast movement of typhoons * Research concerning basic physical processes of meteorological phenomena including dynamic and numerical research of medium- and small-scale phenomena * Research concerning earthquakes and volcanos including comprehensive research concerning actual use of prediction of straight-down-type earthquakes * Research concerning meteorological hydrologic and geological phenomena and other subjects
Ministry of Posts and Telecommunications	* Communications Research Laboratory	* R&D of a space weather forecast system * Research concerning binary frequency Doppler radar for observation of rainfall from space * Research concerning measurement technology of the global environment by means of short-wave length electro-magnetic waves in mill-wave bandwidths * R&D concerning measurement technology of the global environment with optical sphere active sensors * R&D concerning measurement and information networks of the global environment
Ministry of Construction	* Geographical Survey Institute	* Research into and observation of tectonic plate movement using VLBI * Research into and observation of earth crust movement as a means of earthquake prediction
	* Public Works Research Institute	* Research concerning comprehensive preservation technology of national land to cope with global warming

(1) Earth Observation Satellites

Satellites are extremely effective observation tools capable of continuous surveillance over wide areas.

The National Space Development Agency of Japan (NASDA) is operating earth observation satellites including the Marine Observation Satellite-1 (MOS-1) and MOS-1b, and is developing the Earth Resources Satellite (ERS-1) and the Advanced Earth Observing Satellite (ADEOS), in cooperation with related organizations.

The Ministry of International Trade and Industry is promoting the development of an advanced sensor for resources exploration which is to be loaded on the first Polar Orbit Platform of the National Aeronautics and Space Administration (NASA).

NASDA and the Ministry of Posts and Telecommunications are promoting R&D on the Tropical Rainfall Measuring Satellite.

For establishing observation and data processing techniques of the global environment by using satellites, the Science and Technology Agency, in cooperation with related organizations, is encouraging R&D in remote-sensing technology of the environment.

The Ministry of Education is systematically promoting *The Understanding the Global Environment by Satellites Project* with science research subsidies.

The Science and Technology Agency currently is consolidating its databases in preparation for the international networking of information that will allow the effective use of the above-mentioned data obtained from satellite observations.

(2) Marine Observation Technology

Elucidation of the relationships between the oceans and the occurrence of natural phenomena is an important issue in our understanding of global change.

To further knowledge in this area, the Japan Marine Science and Technology Center is promoting several areas of R&D, including the use of the SHINKAI 6500 deep-sea submersible survey vessel and R&D on ocean acoustic tomography.

3.3.1.1.7.3. Science and Technology for Disaster Prevention

Japan is located at the boundary where the Asian continent meets the Pacific Ocean. The nation and comprises an arc-shaped archipelago lying within a zone of mountain ranges that circle the Pacific. The country's land mass is continuously subjected to crustal movements. The country's islands have mountainous topography with many steep slopes, cascading rivers, and few plains. The climate ranges from subtropical to subarctic. Offshore there are both hot and cold ocean currents, such as the Japan or Black Current and the Kuril Current. The changes in seasons are dramatic due to the influence of the Ogasawara air mass in summer, the Siberian air mass in winter, and the Okhotsk air mass during the rainy season. Typhoons spawned in the Western Pacific frequently pass nearby or cross over the islands.

As a result of this geography, the country has experienced almost every possible form of natural disaster caused by air, earth and water--earthquakes, volcanic eruptions, gale-force winds, heavy localized rainfall, floods, high tides and tidal waves.

With this historical background, it is important to gather and fully utilize scientific knowledge on disaster-causing natural phenomena over the entire disaster cycle, from the initial prediction and forecast, through the prediction of an imminent disaster, to its prevention or minimization.

These considerations led the Prime Minister to approve *The Basic Plan for R&D on Disaster Prevention* in July 1981. The Basic Plan outlines the following four areas for priority disaster-prevention research and the development and implementation of countermeasures.

- Establishment of an adequate foundation for

Table 3-3-7. Major research subjects in disaster prevention science and technology (in FY1991)

Ministry or agency	Research institutes, etc.	Subject
Hokkaido Development Agency	Civil Engineering Research Institute, Hokkaido Development Bureau	* Studies on flood prevention, studies on how to prevent road accidents resulting from blizzards and sleet, etc.
Science and Technology Agency	National Research Institute for Earth Science and Disaster Prevention	* Research on crustal activities in the Kanto-Tokai area * Study on prediction techniques for earthquake disasters * Research on natural science and technology of snow disaster prevention in inhabited areas * Research on prediction of volcanic eruption * Research on mechanisms and damage assessment of meteorological disasters * Research on mechanisms and impacts of climate change caused by global warming * A study of disaster predictions in global hydrological processes and other projects
Environment Agency	National Institute for Environmental Studies	* Investigations into proper methods of drawing out groundwater while preventing land subsidence and other projects
Ministry of Education	Universities, etc.	* Studies on natural disasters * Basic earthquake prediction research * Basic research into earthquake damage countermeasures and other projects
Ministry of Agriculture, Forestry and Fisheries	Forestry and Forest Products Research Institute, etc.	* Studies on methods of preventing crop and tree damage and other projects
Ministry of International Trade and Industry	National Research Institute for Pollution and Resources	* Research on mine safety technology (countermeasures against fires, and evacuation systems) * Research on corrosion of apertures in high-pressure gas equipment and other projects
	Geological Survey of Japan	* Research into the mechanisms and locations of earthquake occurrences, etc.
Ministry of Transport	Railway Technical Research Institute	* Development of earthquake disaster prevention and recovery support systems
	Hydrographic Department, Maritime Safety Agency	* Surveys of submarine topography and geological structure
	Meteorological Research Institute, Meteorological Agency	* A study on prediction destructive intraplate earthquakes * Research concerning models of expected courses of typhoons * Studies of weather, land and water phenomena, and etc.
Ministry of Posts and Telecommunications	Communications Research Laboratory	* R&D of high precision technology measuring time and space with cosmic radio waves

(Tab.3-3-7)

Ministry or agency	Research institutes, etc.	Subject
Ministry of Labor	Research Institute of Industrial Safety	* Research into technology to prevent explosions and fire damage caused by new materials * Research on prevention of landslide disasters in drain excavation works and other projects
Ministry of Construction	Geographical Survey Institute	* Geodetic survey of crustal movements, etc. * Research on earthquake and volcanic eruption prediction, etc.
	Building Research Institute, Public Works Research Institute, etc.	* Development of a disaster information system * Research on sediment disaster and river disasters, etc. and other projects
Ministry of Home Affairs	Fire Research Institute, Fire Defence Agency	* Research on countermeasures for large earthquakes and fires * General research on fire disasters

basic disaster-prevention science and technology, including elucidation of the disaster cycle, observation and research for the mechanism of natural phenomena which cause disasters, and measures to prevent or minimize their effects.

- Promotion of R&D projects for disaster prevention taking account of area-dependency of disasters such as heavy snowfall and volcanic eruptions.
- R&D to expand the capabilities of existing technologies applied in earthquake, fire and flood protection and to provide comprehensive and effective disaster-prevention measures for urban areas from a people-centered standpoint by considering cities as a single system.
- General promotion of research for disaster prevention with a wide range of disciplines, including interdisciplinary research, making use of the knowledge of social and behavioral sciences.

In *The Basic Plan for Research and Development on Earth Science and Technology* decided by the Prime Minister in August 1990, the significance of R&D on earth science and technology and the necessity of clarification of environmental variations at a global scale are recommended. R&D of disaster prevention technologies is being conducted also in accordance with these recommendations.

Table 3-3-7 summarizes the R&D subjects in science and technology for disaster prevention by ministries and agencies. Research classifications include earthquake prediction, countermeasures for earthquakes, volcanic eruption prediction, snow- and ice-related disaster countermeasures, wind and water disaster countermeasures and earth science and technology. The research makes use of knowledge from all fields in earth science and technology, space science and technology, ocean science and technology and others.

The Headquarters for Earthquake Prediction, headed by the Minister of State for Science and Technology, conduct seismic studies for use in predicting earthquakes and implements comprehensive, planned measures in response to impending quakes.

At the worldwide level, the Japan International Cooperation Association (JICA) furthers international cooperation by bringing researchers from developing countries to study or train at Japanese research organizations. In FY1990, JICA conducted seminars on disaster-prevention technology applicable to flood and erosion control engineering, and earthquake countermeasures. Training programs were held in earthquake engineering, volcanology, volcanic sabo engineering, and meteorology.

Other international cooperation includes

bilateral programs and *The U.S.-Japan Committee on the Use of Natural Resources* (UJNR), the United Nations *Economic and Social Committee for the Asia-Pacific Region* (ESCAP) *and the World Meteorological Organization* (WMO) Typhoon Committee. In addition, the 1990s have been declared as the International Decade for Natural Disaster Reduction (IDNDR) to encourage international cooperation in reducing human and monetary losses caused by natural disasters. In May 1989, *The* IDNDR *Promotion Headquarters* was established under the directorship of the Prime Minister, and the basic guidelines for its operation were formulated in November of the same year. In this context, an international seminar on earthquake prediction and prevention of earthquake disasters was held in March, 1991.

3.3.1.2. Encouraging Sciences and Technologies for Activating the Economy

The General Guideline for Science and Technology Policy identifies R&D in a number of scientific and technological fields as important stimuli for maintaining steady economic growth. The Guideline cites the promotional objectives listed below, stating that these are able to sustain and develop the health of the nation's economy based on domestic demand in the context of a resurging world economy.

- Development and management of natural resources
- Development and utilization of energy
- Upgrading of production technologies and distribution systems
- Recycling and effective utilization of resources
- Improvement of service to society and life

Since Japan is limited in natural resources, the Guideline emphasizes the need to build a foundation for continued economic growth by encouraging the promotion of technologies that can be used for the development and effective utilization of resources and energy.

3.3.1.2.1. Development and Management of Natural Resources

The Ministry of International Trade and Industry is encouraging R&D of a deep-sea mining system for manganese nodules under its *R&D Program for Large-scale Industrial Technology.* Manganese nodules are rich in nickel, copper, cobalt, manganese and other important metals and are present in abundance on the ocean floor.

The Ministry of Agriculture, Forestry and Fisheries is encouraging research as part of its R&D program in advanced biotechnology. This includes projects to elucidate base sequences of plant DNA and to analyze animal genetic systems.

3.3.1.2.2. Development and Utilization of Nuclear and Non-nuclear Energy

Overall R&D promotion in energy-related fields requires careful prioritization, planning and execution because of the broad range of scientific disciplines involved and the substantial, long-term monetary and personnel investments required. For these reasons, the government has assumed the responsibility to coordinate R&D in energy-related fields.

In August 1978, *The Basic Plan for R&D on Energy* was established. Since then, the plan has been steadily promoted. In June 1991, by taking into consideration the changes in conditions of energy in recent years including global environmental problems, the CST presented *The Recommendation concerning the Basic Plan for R&D on Energy* to the Prime Minister, requesting a substantial revision of the current basic plan. Based on this opinion, the government set down the new Basic Plan for R&D on Energy in July 1991.

3.3.1.2.2.1. Development and Utilization of Nuclear Energy

Nuclear energy facilities are capable of

providing a steady supply of low-cost electricity without discharging harmful gases, such as carbon dioxide or nitrogen oxides, into the atmosphere. For this reason, the government is committed to promoting on-going R&D to strengthen the nation's energy infrastructure by making nuclear energy a primary source of supply.

In June 1987, the Long-term Program for Development and Utilization of Nuclear Energy was formulated by the Atomic Energy Commission. This currently guides the overall planning and promotion of nuclear energy in Japan.

(1) Measures for Assuring Nuclear Safety and Nuclear Non-proliferation

In Japan from the beginning, the development and commercialization of nuclear energy have been conducted with priority to safety and the containment of radioactive materials.

To assure nuclear safety, stringent regulation is conducted by the government that is not observed in other industrial areas. The regulation includes the environmental radiation monitoring, emergency measures for accidents, etc.

To ensure even higher safety, the Nuclear Safety Commission establishes an Annual Nuclear Safety Research Program and evaluates research results to promote safety research comprehensively and systematically.

In accordance with the Annual Nuclear Safety Research Program established in 1990, (three annual safety research plans dealing with nuclear energy facilities, environmental radioactivity, and high-level radioactive wastes established in 1990, and the annual safety research plan for low-level radioactive wastes established in 1989), the following nuclear safety research activities are being promoted.

The Japan Atomic Energy Research Institute (JAERI) is the principal body conducting research into safety in light-water reactor facilities. Of particular concern are possible reactivity accidents and loss of coolant accidents (LOCA).

The Power Reactor and Nuclear Fuel Development Corporation (PNC) and JAERI are responsible for research in all areas of safety for advanced thermal reactors and fast breeder reactors, as well as for nuclear fuel facilities and radioactive treatment and disposal repositories.

The national research institutes are researching the safety of transportation of radioactive materials and seismic safety of nuclear energy facilities.

Both JAERI and PNC conduct research on methods for probablistic assessment of safety and reliability of nuclear power facilities.

The National Institute of Radiological Sciences (NIRS) and other organizations are conducting research on effects of low dose-rate radiation on people, evaluation of the degree of damage through exposure to internal radiation sources by taking into account the peculiarity of the exposure type, and the behavior of radioactive substances in the environment.

In accordance with the *Atomic Energy Basic Law,* Japan's activities in this area are limited for peaceful purposes only and are promoted on the premise of non-proliferation. Accordingly, Japan has accepted the safeguards measures of the International Atomic Energy Agency (IAEA) based on the Nuclear Weapons Non-Proliferation Treaty. Japan implements its national safeguards, and conducts R&D on safeguards technology.

(2) Current State of Nuclear Power Generation

As of July 1991, there were 40 commercial nuclear power plants in operation, with a total output capacity of 32.06 gigawatts. In FY1990, an estimated 26.3% of the nation's electrical power was supplied by these facilities.

Almost all commercial nuclear power in Japan is currently generated using light-water reactors. Here, government organizations, electric utility companies, manufacturers of atomic power generation equipment and other concerned

organizations have cooperated to develop innovative technology that increases the level of reactor reliability, minimizes downtime and reduces employee exposure to radiation.

Since FY1981, JAERI has conducted R&D on technology for decommissioning nuclear reactors using the Japan Power Demonstration Reactor (JPDR) as a test case. The actual dismantling of the JPDR began in FY1986 and removal of radiation shields began in February 1991.

The Nuclear Power Engineering Center also has been conducting tests to verify reactor decommissioning technology since FY1982.

(3) Establishment of a Nuclear Fuel Cycle

In order to promote nuclear power generation continuously and smoothly, establishment of a nuclear fuel cycle aiming at stable fuel supplies and optimal utilization of uranium resources is an important policy issue.

PNC is actively promoting R&D of gas centrifuge uranium enrichment technology which can be used to provide a stable supply of enriched uranium for the nation's power reactors. Currently a commercial uranium enrichment plant, which will use technology successfully demonstrated in tests at PNC, is under construction at Rokkasho-mura in Aomori Prefecture. R&D also has begun into new technologies including laser isotope separation that make uranium enrichment more economical.

It is the government's policy to reprocess spent fuel in order to allow for the optimal utilization of uranium resources.

PNC's Tokai Reprocessing Plant reprocesses spent fuel from the nation's power reactors. As of the end of March 1991, the plant had reprocessed approximately 527 tons of spent fuel. Plans are underway for a commercial reprocessing plant at Rokkasho-mura with an annual reprocessing capacity of approximately 800 tons.

PNC also is conducting R&D on the reprocessing of spent fuel from fast breeder reactors.

Taking measures to treat and dispose of radioactive waste appropriately is a very important issue on the nuclear fuel cycle.

As for low-level radioactive waste, measures are taken to reduce the quantity of waste produced, reduce the waste volume and increase waste solidification.

The plan to bury low-level radioactive solid wastes at shallow depths is underway in Rokkasho-mura. The Prime Minister approved implementation of the plan in November 1990.

The fundamental policy for the disposal of high-level radioactive waste is to vitrify the waste into a stable form, followed by storage for 30 to 50 years for cooling, after which they are to be disposed of underground into a geological formation deeper than several hundred meters.

PNC is a core body in R&D in the technologies for waste, for the storage of vitrified waste and for geological disposal. As a part of these activities and to consolidate geological disposal technology, PNC also is planning to set up the Storage Engineering Center as an integrated research center for storing high-level radioactive waste and other materials.

Separation of nuclides contained in high-level radioactive waste so that useful nuclides can be utilized, and conversion of long-lived nuclides into short-lived, or non-radioactive, nuclides are important research themes. R&D activities are carried out with the cooperation of the JAERI, PNC and other concerned organizations.

(4) Advanced Reactors and Plutonium Utilization

One of Japan's nuclear energy goals is to establish a system for utilizing plutonium recovered by reprocessing spent fuel in order to stabilize the nation's energy supply and to optimize utilization of uranium resources. Fast-breeder reactors will be the principal reactors for the use of plutonium in future.

For some time, plutonium extracted during

reprocessing will be mainly used in light-water reactors and in advanced thermal reactors in order to establish a broad technological base for the use of recovered plutonium. Plans for small-scale testing of mixed uranium and plutonium oxide fuel (MOX) in light-water reactors are underway. This will be followed by full-scale use of MOX fuel in light-water reactors.

PNC has developed the technology for the advanced thermal reactor and the prototype reactor, FUGEN, is now operating well. As for the demonstration reactor, construction is proceeding on the initiative of private firms.

PNC also has carried out extensive development work for the fast breeder reactor. The experimental reactor, JOYO, also has operated well.

With respect to the prototype reactor MONJU which is under construction by PNC (based on the results of JOYO), installation of machines and equipment was completed in April 1991 and function tests started in May 1991, with a goal of going critical toward autumn of 1992. A construction plan for the demonstration reactor is being developed under initiative taken by the utilities. Construction is expected to start in the 2nd half of 1990s.

The plutonium being used in the nation's fast-breeder reactors and in the other R&D programs is provided by reprocessing of nuclear fuel used at Japanese power plants. The reprocessing is done in France and the United Kingdom as well as at Tokai. Present plans call for this material to be returned from Europe by sea, beginning in the autumn of 1992.

(5) Promotion of Advanced Projects

Thermonuclear fusion has a potential of providing a virtually inexhaustible supply of energy for future generations; the world hopes fusion becomes a reality.

In Japan, fusion research activities are carried out at JAERI, the National Institute for Fusion Science of the Ministry of Education, universities and other national research institutes.

Since 1988, JAERI has been developing a performance increasing project called JAERI Tokamak-60 (JT-60). The facility has achieved the world's highest record in the efficiency of plasma current drive. Furthermore, JAERI completed in March 1991 renovation work to achieve greater current thereby enabling the world's pioneering study of plasma confinement to continue.

As for the International Thermonuclear Experimental Reactor (ITER) project, participated in by Japan, the United States, the European Communities and the U.S.S.R., the three-year ITER Conceptual Design Activities (CDA) ended in December 1990. Based on the results of these activities, the 4 partners progressed to the Engineering Design Activities (EDA) and reached an agreement practically in July 1991 about the framework of cooperation and the site of the joint design team. The ITER EDA are expected to begin during FY1991. The National Institute for Fusion Science of the Ministry of Education is supporting the world's largest helical apparatus which uses a superconductive coil to determine the confinement physics of the steady-state operation of the torus magnetic field system and high-temperature plasma.

Radiation has come to be used in a wide range of fields, beginning with the basic sciences and extending into medicine, agriculture and industry. In medical sciences, research is being conducted on the uses of fast neutrons, protons or heavy ion beams to treat malignant tumors, while diagnostic technology employing X-ray computer tomography and X-/γ-ray radiotherapy for malignant tumors already is widely utilized. In particular, the National Institute of Radiological Sciences (NIRS) is using fast neutron and proton beams, and also heavy ion beams for the remarkable treatment of cancer cells. The Institute currently is building a heavy-ion medical accelerator to demonstrate the clinical potential of radiation for cancer

treatment. Research in this area also is underway at some universities. Researchers at Tsukuba University's Proton Medical Research Center, for example, are carrying out studies on the diagnosis and treatment of cancer using proton beams.

In agriculture, forestry and fisheries, radiation is being used for plant breeding, sterilization of vermin, and food irradiation, etc.

In industry, radiation is being used for non-destructive testing for improvement of polymers, etc.

Since FY1987, JAERI has been constructing a multipurpose ion beam facility. Its completion is scheduled for 1992, although it began partial operation in FY1991.

JAERI and the Institute of Physical and Chemical Research (RIKEN) have been constructing since FY1989 a next-generation synchrotron radiation facility (SPring-8) at the Harima Science Garden City in Hyogo Prefecture. Its completion is scheduled for FY1998. The High-Energy Physics Research Institute of the Ministry of Education also has been conducting high-intensity synchrotron radiation research using the "TRISTAN" injection-accumulation ring.

A promising field for R&D in high-temperature engineering is the generation of energy using high-temperature gas reactors. Advances in this field hold the promise of opening up many possible alternative sources of energy. JAERI is now constructing a high-temperature engineering test reactor (HTTR), with the goal of establishing high-temperature gas reactor technology and pioneering basic research into high-temperature phenomena.

JAERI also is promoting the nation's R&D of technologies for use in nuclear-powered ships. The Institute constructed and has been conducting startup tests of the Mutsu nuclear-powered ship. In March to December 1990, reactor capacity tests for increasing output and offshore exercises of the ship were performed. In February 1991, after having received a certificate of success, based on the pre-use inspection under the Nuclear Reactor Regulation Act, and the ships inspection certificate, based on the Ships Safety Act, the Mutsu began a year-long series of test voyages to obtain knowledge concerning the effects of vibration, pitching and rolling, and variations in load based on a variety of high-seas conditions. Also, design evaluation research is being conducted to improve the economy and reliability of the ship's reactors.

In addition to the above programs, JAERI, the national universities and the national research institutes are furthering basic research in the following fields.

- Nuclear and reactor physics
- The physiological effects of radiation
- Irradiation testing of fuel assemblies and materials

Also JAERI, PNC, RIKEN and the national research institutes are developing a number of underlying technologies in the following four areas.

- Materials technology for nuclear facilities
- Artificial intelligence technology for nuclear facilities
- Laser technology for the nuclear energy field
- Technology for assessment and reduction of radiation risk

(6) Contribution to the World Community

While developing nuclear energy, nations have become interdependent, making international cooperation an important factor in ensuring that R&D in this area are carried out as efficiently as possible.

Japan's efforts in nuclear energy R&D are both bilateral and multilateral. Bilateral activities include information sharing, exchanges of personnel and joint research projects. Multilateral activities are encouraged at national government levels through treaties and agreements and through support provided to international organizations. Japan also is

cooperating with developing countries through regional projects with neighboring Asian nations including the sponsorship of the International Conference of Nuclear Cooperation in Asia. In May 1990, Japan concluded with the Republic of Korea the Japan-Korea Agreement for Cooperation concerning Peaceful Uses of Nuclear Energy, and in July 1991, the revised Japan-France Agreement for Cooperation concerning Peaceful Uses of Nuclear Energy came into effect. In April 1991, the Japan-Soviet Agreement for Cooperation concerning Peaceful Uses of Nuclear Energy was concluded.

(7) Public Acceptance of Nuclear Energy

Public acceptance and cooperation are essential to the smooth development and utilization of nuclear energy. The government is conducting public awareness activities and is soliciting public cooperation and, for this purpose, is taking all measures possible for security and safety. In addition, the government disseminates information on nuclear energy through the mass media and also encoureges public relations at the grass-roots level through lectures and study groups.

3.3.1.2.2.2. R&D on Natural Energy

The practical use of solar energy, geothermal energy, ocean energy, wind energy, biomass energy and other natural energy alternatives faces a number of obstacles that are largely due to the characteristics of these resources. However, it is important to overcome the various problems that impede their development, since natural sources of energy are clean and, unlike fossil fuels, do not discharge carbon dioxide, the principle cause of global warming. Eventual widespread use of such energy can only have a positive effect on global environmental issues.

R&D on natural energy is being carried out at the Institute of Physical and Chemical Research, the Japan Marine Science and Technology Center, as well as through work on the New Energy Technology Development Program (the Sunshine Project and other related programs).

Solar energy can be utilized for hot water supply, heating, cooling, photovoltaic power generation and other needs. Technological development of solar water heater systems for residential use has been completed and the system is spreading among general households. R&D into technologies to promote the industrial use of solar energy are underway. The government also is encouraging R&D on photovoltaic power generation with the goal of substantially lowering the cost of solar batteries and their systems while improving their efficiency.

Geothermal energy resources are abundant and its use as an energy source close to local communities is being considered, for example, in space heating, cultivation of the crops, etc. In this context, R&D is progressing on techniques assessing deposits of geothermal resources, technology for exploration, drilling and extraction of geothermal resources, binary cycle power generation systems using hot water with medium and high temperature and hot dry rock power generation systems. Also development of multipurpose use technology of geothermal energy and technology for preservation of the environment are progressing.

Ocean energy can be used in different ways depending on conditions in each particular area. R&D are progressing in the application of efficient wave energy utilization systems, ocean thermal energy conversion systems and others. R&D also are being furthered on combined systems that would integrate these technologies with power generation by breakwaters and the use of deep-sea water.

Wind-powered energy already has been introduced and widely used as a part of electric power supply sources in Europe and America. Japan is now promoting the R&D of medium- and small-scale wind powered generation systems. Also, the R&D of large-scale wind power generation systems are progressing toward the

goal of expanding use of wind energy.

The development of biological energy technology including photosynthesis is faced with many obstacles, including the low energy output density of the energy sources, and difficulties in transport and storage. However, the government is encouraging R&D to further the use of such energy resources, since they are not only renewable, but would have little or no negative impact on the environment.

3.3.1.2.2.3. R&D on Fossil Energy

Oil is Japan's principle source of energy and the government is encouraging R&D of technologies for oil development to offset the effect of deteriorating conditions in the petroleum industry, such as the diminishing capacities of new oil fields.

Coal, as well as nuclear energy, is used as an alternative to oil and the government is encouraging R&D of new technologies. For example, R&D in such fields as coal liquefaction technology, combined cycle power generation technology integrated with low-calorie coal gassification, and technology to produce hydrogen from coal are being encouraged as part of the Sunshine Project.

Natural gas also is being used as an alternative to oil, especially since it is a clean source of energy that has minimal negative effect on the environment. Here the government encourages R&D in areas which can make the most efficient and economical use of this resource, such as prospecting, liquefaction, transportation, and storage.

3.3.1.2.2.4. R&D for More Efficient Use of Energy

From the viewpoints of assurance of a stable supply of energy, counteraction to global environmental issues and effective use of limited energy resources, it has become essential to bolster the R&D of more efficient use of energy in each stage from its supply to end use.

The government is actively promoting R&D on energy conservation technologies in the industry and household sectors (the Moonlight Project) and R&D for more efficient use in the transportation sector and buildings.

More specifically, under the Moonlight Project, R&D is being conducting in the following fields.

- High thermal efficiency ceramic gas turbines that can be used in co-generation systems
- Fuel cell technology for clean, efficient power generation
- Superconducting materials and superconducting power generation systems and technology
- Super heat-pump energy accumulation systems capable of high-density, high-efficiency energy storage
- New types of batteries

In transportation, R&D on a number of new propulsion systems are underway to establish a technology base capable of using a wider variety of energy sources. The following systems are representative of the efforts being made in this area.

- Ceramic gas turbines and engines
- Stirling engines
- Alcohol engines
- Natural gas engines

Other energy conservation areas in which R&D has the government's support include the following.

- Systems technology for utilizing waste heat in factories, power stations and urban areas
- Technology for fermenting, distilling, and using industrial alcohol derived from agricultural, forestry and fishery resources
- Technologies to distribute energy sources appropriate to different locales
- System technology for utilizing hydrogen energy which does not discharge carbon dioxide during combustion

3.3.1.2.3. Upgrading of Production Technologies and Distribution Systems

The government is encouraging R&D in improving the nation's production technology

and distribution systems. In food production, R&D of the foundations for production, cultivation and packaging are being undertaken. The National Research and Development Program (a large-scale project) currently is furthering the development of *Super-Frontier Processing Systems* dealing with processing technology using excimer laser ion beams and ultra-precise processing technologies.

3.3.1.2.4. Recycling and Effective Utilization of Resources

The government is promoting R&D projects dealing with use of recyclable resources.

By means of large-scale projects, studies are being conducted on high-functional chemical product production methods contributing to the effective use of marine biological resources by using biotechnology (effective use of marine organisms).

The Ministry of Agriculture, Forestry and Fisheries is encouraging general research in areas related to the development of technologies for the efficient use of biological resources.

3.3.1.2.5. Improvement of Service to Society and Life

The government is supporting R&D to improve services both at individual and community levels. Areas being promoted include research on man-machine-interfaces, R&D of technologies to measure human sensory response factors and to develop space at great depths underground, and studies to develop new transportation systems and new distribution systems.

The R&D of micro-machining technology, in which a micro-machine carries out sophisticated operations including inspection, repair, or remedy, also is progressing.

3.3.1.3. Encouraging Science and Technology for Improving the Quality of Society and Life

Japanese society is maturing and, at the same time, is being encouraged to expand its role in the world community by furthering international exchanges and cooperation. In this context, the government recognizes the need to develop science and technology in ways that place greater emphasis on the needs of individuals and society and which also encourage continued, healthy growth.

In March 1986, the cabinet approved *The General Guideline for Science and Technology Policy* based on the Recommendation pursuant to Inquiry No. 11 submitted by the CST in November 1984. The General Guideline stated the importance of encouraging science and technology for the advancement of society and the enrichment of individual life.

In accordance with the General Guideline and guidelines laid down by other policy-making bodies, various ministries and agencies are furthering a variety of R&D programs and these are described in the following sections.

3.3.1.3.1. Maintaining and Improving the Mental and Physical Health of the People

Public concern for maintaining better levels of mental and physical health has grown as living standards have risen. Until recent days, public health policies have focused on treating illness and disability. The government is now faced, however, with increased public awareness of healthier lifestyles as a part of everyday life. To meet this need, the government is encouraging R&D related to the maintenance and enhancement of mental and physical health and the fostering of new concepts in medical care.

A number of government organizations have formulated policies and published recommendations that have established government priorities for R&D in health-related areas. Some

of the key documents which have been drawn up include the following.

- *Opinions on Basic Guidelines for Promoting Neurological Science and Technology,* submitted in August 1987 by the CST
- *Opinions on Basic Guidelines for Promoting Immunological Science and Technology,* submitted in August 1987 by the CST
- *Guidelines for General Anti-AIDS Policies,* submitted in February 1987 by the Cabinet Council for AIDS-Counter Measures
- *Opinions on Basic Guidelines for Promoting Cancer Research,* submitted in July 1983 by the CST
- *Ten-year General Anti-cancer Strategy,* submitted in June 1983 by the Cabinet Council for Cancer-Counter Measures

The Science and Technology Agency, the Ministry of Health and Welfare, the Ministry of Education and the Ministry of International Trade and Industry are undertaking R&D programs in the following areas.

- Research on the maintenance function of a living organism's homeostatis
- Studies on disabilities
- Analysis of the bio-regulatory mechanisms for various food products
- Technology for the diagnosis and treatment of cancer, diseases of the circulatory system and current incurable diseases
- Development of medical treatment systems
- Development of diagnostic and therapeutic equipment and artificial organs

3.3.1.3.2. Formulation of Individual and Cultural Life

Dealing with issues such as improving the quality of life, meeting the needs of an aging society and making adjustments to the decline in the birthrate, are primarily the responsibilities of the local community, the family and the individual. However, despite the limitations of science and technology in dealing with such issues, many people feel that properly focused scientific R&D can make a substantial contribution.

The CST has addressed these issues and set out R&D priorities in *Opinions on Basic Guidelines for Promoting Science and Technology Appropriate to Long-lived Populations,* submitted to the Prime Minister in May 1986. Based on this, the government is encouraging R&D in areas related to lifestyle improvement, support for various cultural activities, the fostering of safe, livable communities and adjustment to a prolonged demographic shift toward an aging population.

In this regard, the Ministry of Health and Welfare, the Ministry of International Trade and Industry, the Ministry of Posts and Telecommunications, the Ministry of Labor and the Ministry of Construction are encouraging R&D in the following areas.

- Development of new materials for construction
- Development of appliances and equipment support systems for residential dwellings
- Measures to ensure the safe handling of substances used in daily life
- Development of equipment designed especially for the needs of senior citizens

3.3.1.3.3. Formulation of a Comfortable and Safe Society

Increased urbanization and the rapid development of roads, transportation and communications systems have made society more complex, making the maintenance of a good living environment in pleasant neighborhoods with a distinctive character a government priority. This can be attained by encouraging R&D in the following areas.

- Fostering of safe and pleasant neighborhoods
- Consolidation of roads, transport and communication systems
- Improved safety and disaster-prevention measures
- Environmental preservation

A number of government organizations have formulated policies and published recommenda-

tions that establish priorities for furthering R&D in these areas. Some of these documents are as follows.

- *Long-term Perspectives on R&D of Construction Technology,* published in April 1988 by the Ministry of Construction
- *Basic R&D Programs at the Ministry of Transport,* published annually by the Ministry of Transport
- *R&D Directives for Telecommunications Technology,* published in August 1987 by the Ministry of Posts and Telecommunications
- *Basic Measures concerning Development of Information and Communications Technologies in Prospect of the 21st Century,* published in June 1991 by the Council on Telecommunications Technology, the Ministry of Posts and Telecommunications
- *Basic R&D Programs for Disaster Prevention,* approved by the Prime Minister in July 1981
- *Emphasis on Priorities and the General Promotion of Experimental Research Related to Pollution Prevention,* published annually by the Environment Agency.

The National Police Agency, the Science and Technology Agency, the Environment Agency, the Ministry of Agriculture, Forestry and Fisheries, the Ministry of Transport, the Ministry of Posts and Telecommunications, the Ministry of Labor and the Ministry of Construction are the primary organizations encouraging R&D through implementation of projects in the following areas.

- Urban and agricultural-community planning
- Development of construction technology
- Technology for the support and management of urban services
- Development of new systems for communicating information
- Elucidation of causal mechanisms related to natural disasters, their forecast and prediction
- Insurance of safe and hygienic work conditions
- Prevention of environmental contamination

The Science and Technology Agency, the Ministry of Transport and the Ministry of Construction are the primary organizations promoting R&D projects in the following areas.

- Prediction of earthquakes and volcanic eruptions
- Component technologies for aeronautical application

3.3.1.3.4. Improving the Human Environment Based on a Global Viewpoint

Recently, to solve the problem of environmental deterioration it becomes increasingly important to cooperate internationally. Given today's interdependency among nations, it is important for the technologically advanced nations to use their R&D capabilities to meet the challenge of global environmental problems.

The following documents address these issues and also establish government R&D priorities.

- *General Investigation and Research Promotion Programs for Global Environment Conservation,* FY1991, published in June 1991 by the Council of Ministers for Global Environment Conservation.
- *Basic Plan for R&D on Earth Science and Technology,* based on Recommendation of the CST pursuant to Inquiry No. 17, approved by the Prime Minister in August 1990

Based on these, Japan is committed to the following programs.

- Response to environmental problems of global concern
- Fostering mutual understanding among nations
- Provision of assistance to developing countries for the purpose of improving their societies and standard of living

More specifically, the Science and Technology Agency, the Environment Agency, the Ministry of Education, the Ministry of Agriculture, Forestry and Fisheries, the Ministry of International Trade and Industry, the Ministry of Posts and Telecommunications and on the

Ministry of Construction are promoting R&D on the analysis and evaluation of global environmental changes and the technologies for appropriate countermeasures.

3.3.2. Research Activities by Organization

3.3.2.1. Research Activities at the National Research Institutes

The national research institutes conduct specific research activities under the auspices of the ministry or agency with which they are affiliated. In FY1991, expenditures by the national research institutes for experimental

Table 3-3-8. Breakdown of expenditures for national research institutes by ministry or agency (million yen)

Ministry or agency	Fiscal Year	
	1990	1991
National Police Agency	1,055	1,143
Hokkaido Development Agency	149	148
Defense Agency	103,241	113,974
Economic Planning Agency	809	850
Science and Technology Agency	36,223	39,184
Environment Agency	6,828	7,905
Ministry of Justice	939	1,006
Ministry or Finance	1,088	1,193
Ministry of Education	7,050	7,411
Ministry of Health and Welfare	15,707	16,926
Ministry of Agriculture, Forestry and Fisheries	59,221	62,421
Ministry of International Trade and Industry	40,849	42,690
Ministry of Transport	8,588	9,387
Ministry of Posts and Telecommunications	4,468	5,072
Ministry of Labor	2,432	3,152
Ministry of Construction	5,232	5,846
Ministry of Home Affairs	565	616
Total	294,444	318,923

Note: 1. Since amounts have been rounded, the sum of the amounts for each column and the totals shown above do not necessarily agree.
2. Amounts include expenditures for the humanities.

research costs, personnel costs and facility costs were 318.9 billion yen, up 8.3% from the previous year. Table 3-3-8 lists these expenditures by ministry and agency.

A total of 14,777 people were employed in 1991, including 9,660 researchers. This was down 99 from the previous year, including 39 fewer researchers.

3.3.2.1.1. Ordinary Research and Special Research

Ordinary research consists principally of research activities in comparatively basic fields that is conducted on a regular basis to provide the foundation for other research activities.

Special research, unlike ordinary research, consists of planned research activities that must be conducted expeditiously within a fixed time period to meet societal or governmental requirements.

3.3.2.1.2. Guidelines for Promoting Basic Research at Research Institutes

Looking forward to the 21st century, Japan is committed to promoting creativity in science and technology and especially in basic research for the betterment of society at home and abroad.

For the promotion of basic research the national institute are highly expected as well as universities.

In this context, a number of highly promising basic research projects are currently underway at the national research institutes, national universities,etc. Since this basic research provides the impetus for development of innovative technologies, the Science and Technology Agency utilizes the Special Coordination Funds for Promoting Science and Technology in the following ways to support R&D in national research institutes in accordance with the directives of the CST.

- Encouragement of Basic Research at national research institutes to create the seeds of innovative technologies (since FY1985)
- International Core System for Basic Research to promote international research exchanges (since FY1988)

By means of this latter system, the national research institutes have been conducting research across jurisdictional territories, bringing together researchers from different countries.

In FY1990, the science and technology special researcher system was established and implemented for activities in national research institutes by accepting young researchers in these institutes as part-time employees.

3.3.2.2. Research Activities at Public Research Corporations

In addition to the national research institutes, important government-sponsored research activities are conducted at public research corporations. Funding for these corporations is provided by government investments and subsidies as well as by private sector investment. They are effective vehicles for research since they allow for flexible management, are able to recruit researchers from a wide range of government and private-sector organizations and can finance their activities with investments from the private sector.

Public research corporations are destined to play an important role in Japanese R&D as they are capable of sustaining the comprehensive efforts required to accommodate the growing volume of large-scale, complex projects.

Table 3-3-9 lists the main purposes and research activities provided by the principal public research corporations.

3.3.2.3. Research Activities at Academic Institutions

Academic institutions conduct research with the goal of extending knowledge. At these institutions, innovation and creativity are fostered in an environment that encourages independence, inquisitiveness and the free

Table 3-3-9. Public Research Corporations

Organization	Purpose and activities
Japan Atomic Energy Research Institute (JAERI)	To carry out comprehensive, efficient research on nuclear energy development; conduct basic and applied research on nuclear energy; nuclear reactor design, construction and operation; R&D of nuclear-powered ships; and to disseminate information and technologies.
Institute of Physical and Chemical Research (RIKEN)	To develop original, innovative technologies, conduct broad-ranging, advanced experimental basic and applied research level in physics, chemistry, agricultural science, biology and other fields; to disseminate information and technologies to the academic and industrial sectors.
Research Development Corporation of Japan (JRDC)	To commission development of new technologies, and basic research deemed necessary to develop new technologies, to disseminate information and technologies; grant concessions for the development of new technologies; promote communication among the international research community; supply information pertinent to the international research community.
Power Reactor and Nuclear Fuel Development Corporation (PNC)	Primary development work is to establish key elements of the nuclear fuel cycle, including fuel development, uranium prospecting and mining, reprocessing of spent fuel, development of autonomous technology for fast breeder reactors, and new types of conversion reactors.
National Space Development Agency of Japan (NASDA)	To contribute to space science and technology and the utilization of the space environment for peaceful purposes, conduct general development of satellites and the launch vehicles to launch them, and to manage launching and tracking operations.
Japan Marine Science and Technology Center (JAMSTEC)	To further science and technology useful in ocean development; conduct general experimental research, including R&D of submersibles for deep-sea surveys, R&D of technologies for undersea work; to commission and manage large, joint-use facilities for experimental research, conduct training programs, information gathering and dissemination.
New Energy and Industrial Technology Development Organization (NEDO)	To improve Japan's industrial technologies and to further international exchange in the field of industrial technology; conduct R&D of technologies for industrial use; establish a research infrastructure; promote joint international research.

dissemination of ideas.

Japan's national and private universities and colleges lie at the center of this activity and are charged with maintaining and raising the standard of the nation's academic work. The universities and colleges promote academic development by paying high regard to the independence of researchers and encouraging education and research to mature together in studies that are focused around the humanities, social sciences and natural sciences.

The Ministry of Education supports research activities in departments of universities and colleges, their attached laboratories and research institutes and in inter-university research institutes. Although education and research activities are basically treated as two parts of an inseparable whole, for accounting purposes, expenditures designated for research can be classified into the following categories.

- Expenditures for ordinary research
- Expenditures for separately accountable research granted on the basis of research content and need
- Expenditures for research on specific projects
- Expenditures for installment and maintenance of research facilities and equipment.

Expenditures for ordinary research to

providing the foundation to conduct research independently, consist, at the national universities and colleges, of personnel expenses, research expenses by faculty members and research-related travel expenses by faculty members. The Ministry of Education supports personnel expenses and overall education and research costs for private universities and colleges through subsidies for working expenditures.

There are a number of expenditures allocated to cover the cost of special research, one of which is the Ministry of Education's Grant-in-aid for Scientific Research to promote of advanced scientific research in fields that contribute to the furtherance of the sciences in Japan. This grant-in-aid covers the cost of independently planned research projects by a researcher or group of researchers affiliated with an academic institution which are deemed to be in the national interest for the furtherance of academic knowledge and for which outstanding results may be obtained. This grant-in-aid has been instrumental in furthering scientific research in Japan by encouraging creative and innovative scientific research and by nurturing the formation of distinguished research groups.

In FY1990, *The Originative Basic Research Expenditures* were established to improve research activities and promote new scientific programs. This, as well as other grants-in-aid, supported research in the following areas. See also Table 3-3-10.

- Research in priority areas for promoting advanced research, for example, in the materials science areas
- "General Research (B) and (C)" for encouraging creative and innovative basic research and for developing social sciences and humanities
- "Research Encouragement (A)" to promote work by capable young researchers
- "Experimental Research" for promoting both experimental and applications research
- "International Scientific Research" for promoting international joint research projects
- Expenditures for promoting the dissemination of research results

The encouragement of capable, young researchers is also an issue of critical importance in furthering scientific research. To promote these efforts, the Science Council made a proposal to the Minister of Education in July 1990. In FY1985, the Ministry of Education addressed this issue by establishing the "Special Researcher Fellowship Program," a full-fellowship program under the auspices of the Japan Society for the Promotion of Science (JSPS). The program enables students attending the later period of doctor degree programs in graduate schools and those who have obtained the doctotare degree to devote themselves to independent creative research. The Ministry of Education has expanded the program on a yearly basis, so that in FY1990 the program supported a total of 1,000 research fellows.

In recent years, scientific investigators at universities have been besieged with requests by private industry and other sectors of society. To address this, the Ministry of Education has implemented a number of measures that enable them to cooperate with private industry on joint research projects that meet the needs of society in an appropriate manner, while protecting the autonomy of the universities.

In FY1983, the Ministry of Education established the "University-Private-sector Joint Research Program" to allow national universities and other institutions to accept researchers and research funding from private industry. These researchers collaborate equally with university researchers on joint research projects of common interest.

Researchers, both at universities and in the private sector, have expressed strong interest in this program. As of FY1990, 869 joint projects had been conducted under this program for the development of materials, equipment, software and other technology. From FY1987, the

Table 3-3-10. Research classifications and budget allocations of the Grant-in- Aid for Scientific Research in FY1990

Research classification		Description	Budget (million yen)
Scientific research expenditures		Support for research expenses	53,600
	High-priority research	Research projects with the potential to show outstanding results in fields whose importance has been internationally recognized.	2,360
	Special research	Long-term research projects that address pressing academic or social needs, such as cancer research.	2,100
	Priority research	Dynamic, intensive research projects carried out over a fixed term (3 to 6 years) that address pressing scientific or social needs, including work involving materials, the life sciences, earth sciences, and space sciences.	14,330
	Comprehensive joint research program	Joint, interdisciplinary research projects spanning organizations and scientists in different disciplines	2,740
	General research	Individual or group research projects within a single organization. With the following budget classifications (A) 10 million yen up to less than 50 million yen (B) 3 million yen up to less than 10 million yen (C) Less than 3 million yen	17,150
	Experimental research	Experimental or applied research projects with potential for commercial use	4,850
	Encourage research (Special researchers)	Research to be conducted by special researchers of the Japan Society for the Promotion of Science	990
	Commendatory research (A)	Research projects conducted independently by a young researcher with a budget of under 1.2 million yen	4,090
	Commendatory research (B)	Research projects conducted independently by a kindergarten, elementary, middle, or high school teacher, or by a private citizen with a budget under 300,000 yen	90
	International scientific research	Scientific investigation, international joint research and other investigative research of international scope	2,950
	Extraordinary Research Promotion Funds	Support for urgent research in important fields	1,950
Research reporting expenditures		Assistance for reporting or disseminating literature on important academic research findings	1,400
Special Commendatory Research		Funds awarded to promote unique research projects by private sector scientific research organizations in fields that address pressing scientific or social needs.	400
Originative basic research expenditures		Promotion of new programs in science	400
Total			55,800

Ministry has commissioned "Joint Research Centers" at national universities for joint research projects and other areas of academic and private-sector cooperation. The Ministry also is promoting private-industry and university cooperation on joint research by making it easier for colleges and universities to undertake contract research and accept contract researchers. Funds for this are provided through the Grant-in-Aid for Scientific Research. The Japan Society for the Promotion of Science also is encouraging academic-private sector cooperative activities through its General Liaison Committee.

Academic research is an all-encompassing intellectual endeavor that helps further knowledge regarding ourselves and our universe. Thus, expanding the frontiers of academic research requires cooperation and a free exchange of ideas across national boundaries. Over the last few years, the need for international effort to deal with resource and energy problems and global environmental problems has intensified. Moreover, many fields of scientific research, such as high-energy physics and nuclear fusion, require large-scale facilities and advanced equipment that are often beyond the capital resources of any single nation.

To address these issues, Japan is encouraging international cooperation in scientific research in the following areas.

- Invitation of researchers from overseas to conduct research in Japan under the Special Overseas Researcher Fellowship Program
- Dispatch of Japanese researchers to participate in R&D activities overseas
- Encouragement of joint bilateral and multilateral research projects

Japan is involved in large-scale, international joint research projects under various agreements, both at the international and inter-organization levels. Research activities also are conducted under multilateral agreements with the International Council of Scientific Union (ICSU), the United Nations Educational, Scientific and Cultural Organization (UNESCO)and other international bodies. The Ministry of Education also is actively encouraging university exchange programs with developing countries.

Research activities in universities and colleges have been promoted, in line with the purport of the 1984 Science Council recommendation *Principal Measures for Improving Academic Research Systems.* However, to cope with substantial changes in conditions surrounding academic research in recent years, the Minister of Education inquired about *Comprehensive Promotion Measures for Academic Research in Prospect of the 21st Century* to the Science Council in December 1990. The Council has been deliberating from a long-term and comprehensive viewpoint various problems including the basic conceptions of academic research, improvements in research systems, steady recruitment of researchers, increases of research expenditures and promotion of international academic exchanges.

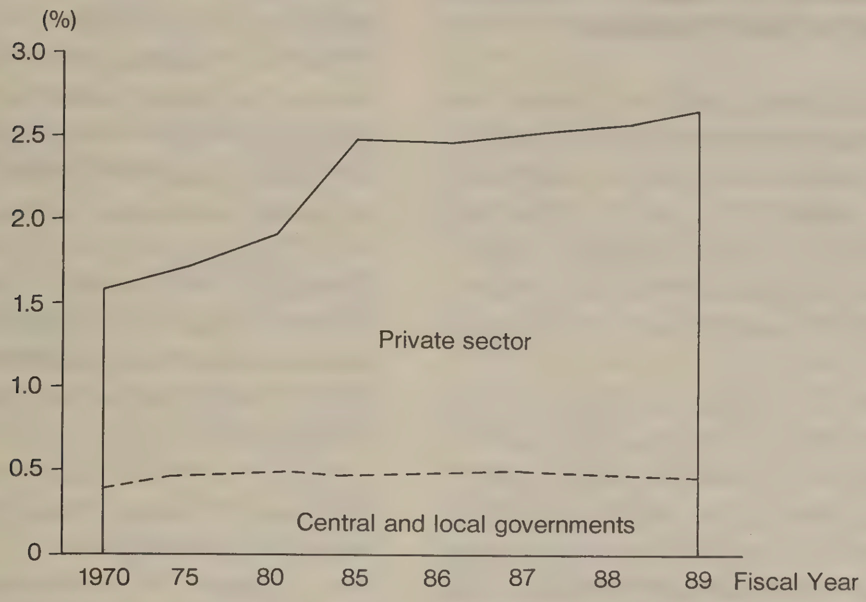
3.3.3. Strengthening the Infrastructure for Science and Technology Promotion

A strong promotional infrastructure is a prerequisite for the smooth and efficient progress of R&D in science and technology toward meeting various needs in and out of the country.

The government is addressing this issue through its implementation of the following measures.

- Increased expenditures on R&D
- Nurturing of research personnel and improving their treatment
- Management and supply of equipment and facilities, materials and genetic resources
- Promotion of the research exchange
- Dissemination of science and technological information
- Promotion of regional science and technology
- Promotion of research activities in the private sector

Figure 3-3-11. Research expenditures by sector as a percentage of GNP



3.3.3.1. R&D Expenditures

The CST Recommendation pursuant to Inquiry No. 11 submitted in November 1984 sets out Japan's basic priorities for determining expenditures on R&D. The recommendation points out the need for the government's continuing financial investment in R&D in order to provide the pool of intellectual resources required to develop the nation's science and technology base for the next century. It also states that a strong infrastructure is a prerequisite for basic research and for the expansion of research in directions that will solidify the infrastructure for socioeconomic growth. The recommendation further states that the government should address these issues by increasing R&D expenditures and by consolidating and improving the conditions for conducting R&D in the private sector.

In FY1989, the government invested 1,900 billion yen on R&D, up 3.7% over the previous year. The money was spent primarily in areas deemed to be of national importance, such as conducting basic research, encouraging large-scale research projects and improving the infrastructure of R&D. The government's share of research funding relative to Gross National Product was 0.5%, lower than in the U.S. and European countries. Only 13% of the total R&D expenditures in Japan was spent on basic research (Figure 3-3-11). Given this record, a continued increase in R&D investments by the government is desired.

Based on current trends, private sector investments in R&D are expected to rise. In light of this, the government is making it more attractive for the private sector to increase investments through the implementation of the following tax measures and programs.

- *Tax Deductions on Experimental and Research Expense Increments*
- Exemptions under *The Tax Program for Promoting R&D of Basic Technologies*
- *Cooperative Development for Industrial Technology* for the development and commercial application of new technologies
- Credit guarantee programs

3.3.3.2. Nurturing of Research Personnel and Improving of Their Treatment

Progress and development of science and technology is heavily dependent on the abilities and creativity of those involved in R&D work. Accordingly, efforts to nurture, sustain and improve scientific and technically-trained personnel are prerequisites for the effective promotion of science and technology development.

As part of its efforts, the Science and Technology Agency (STA) has implemented programs designed to raise the quality of work done by researchers and to stimulate research work at the national research institutes through study-exchange activities both at home and abroad. In FY1989, the STA supplemented these programs by establishing the Special Researcher Program for the Basic Sciences at the Institute of Physical and Chemical Research where capable young researchers could engage in self-initiated, independent research, and in FY1990, by inaugurating the National Institute Post Doctoral Fellowship Program to accept young investigators with abundant creativity in national research institutes.

The Ministry of Education also has been nurturing highly capable, young researchers by consolidating and expanding programs and facilities at graduate schools and other institutions of higher learning. The Ministry established the Special Researcher Fellowship Program in FY1985 under the direction of the Japan Society for the Promotion of Science.

STA has recognized that good treatment of research personnel is a prerequisite for retaining capable researchers and for allowing them to reach their full potential. Since 1961, STA has coordinated the opinions of the various ministries and agencies and has made an annual request to the National Personnel Authority regarding the employment conditions of government researchers. In FY1990, STA requested two measures designed to retain staff by closing the gap between the salaries of researchers and educators.

The first measure stated the desirability of revising the salary scales for research workers (especially for those newly appointed researchers and young researchers where discrepancies are particularly noticeable) to bring them into line with *The Salary Scale 1 for Teaching Staff* (applicable to tenured staff at national universities and other institutions), which itself had been specially upgraded to keep step with the salaries being paid to teachers at compulsory education schools.

The second measure stated the desirability of improving the salaries of researchers assigned to Tsukuba Science City.

As a result of these requests, the average salaries of young researchers (research staff grade 2) and teaching staff grade 2 on *The Salary Scale 1 for Teaching Staff* were revised by 4.9% and 3.7%, respectively, placing the average salaries for research staff grade 2 higher than the average salary of young teaching staff on grade 2. The starting salaries of newly appointed teachers with bachelor degrees on the Salary Scale 1 rose to a level higher than that of researchers because of the up-grade of the starting salary on *The Salary Scale 1 for Teaching Staff,* while the salaries of researchers with masters or doctoral degrees rose to a level higher than that of educators on *Salary Scale 1 for Teaching Staff.*

3.3.3.3. Management and Supply of Equipment and Facilities, Materials and Genetic Resources

In accordance with *The Basic Directives for Consolidating the Infrastructure for Science and Technology Promotion,* approved by the Prime Minister in January 1990, the various ministries and agencies are promoting measures to implement the following.

- Establishment of a system to ensure a more complete system of supply for the materials

and genetic resources used in research

- Replacement of obsolete and outdated equipment and facilities at national universities and the national research institutes
- Development of the world's most advanced equipment and consolidation of core research functions
- Creation of favorable work environments at national universities and at national research institutes to conduct more joint research projects with outside researchers

In the area of biological research materials and genetic resources, the Institute of Physical and Chemical Research (RIKEN) has established a gene bank program for the collection, storage and distribution of the animal and plant cell cultures and genes required for research in the life sciences. Other RIKEN programs include the development of an information system for experimental data in the biological sciences, the development of test animals, and the collection, storage and apportionment of microorganism strains.

The Ministry of Education is setting up animal testing facilities as a part of the overall reorganization of its research support infrastructure at the national universities.

The Ministry of Health and Welfare is operating a Research Resources Bank that collects, stores and distributes human and animal cell cultures needed for the cancer research carried out under the 10-year comprehensive anti-cancer strategy.

The Ministry of Agriculture, Forestry and Fisheries is promoting the operation of MAFF Gene Bank, which collects and stores genetic resources from all types of agricultural, forestry and fishery resources, including plants and trees, animals, marine life and microorganisms. The gene bank also supplies genetic resources and information in stock to researchers.

The Ministry of International Trade and Industry at its Fermentation Research Institute Patented Microorganism Depository,deposits and distributes microorganisms related to patent research as well as conducts research on preservation technologies for use with plant and animal cells.

As one of its projects for improving research and development infrastructure, the Science and Technology Agency is constructing the Next-Generation Synchrotron Radiation Facility "SPring-8" in the Harima Science Garden City, Hyogo Prefecture. RIKEN and the Japan Atomic Energy Research Institute (JAERI) are jointly implementing the enterprise. It will be the largest synchrotron radiation facility in the world with 8GeV stored electron energy. It also will perform as a source with higher brilliance and harder X-rays than conventional synchrotron radiation facilities. This facility can be used for research carried out in a wide range of science and technology fields, including materials science, electronics and life sciences. It will be a joint use facility opened to researchers both at home and abroad.

This SPring-8 is expected to not only help to further basic and creative R&D, but also to play a key role in international research cooperation.

R&D activities and manufacturing of instruments are to be continued as in 1990 and construction of the building will be started in 1991. The facility is scheduled to be completed and ready for general use in 1998.

Currently, European countries and the U.S. are planning to construct similar facilities.

In a similar vein, the High-Energy Physics Research Institute (KEK) of the Ministry of Education has begun high-advanced research using the "TRISTAN" injection accumulation ring.

Based on the Act for Construction of R&D Structures concerning Industrial Technologies, the Ministry of International Trade and Industry, under the Research Foundation Construction Project, is constructing those research facilities which are necessary for sophisticated R&D that should be promoted in this country in the future but which are difficult to construct only by the

efforts of the private sector. In this project, a third-sector enterprise, to be established with investment from the New Energy Comprehensive Research and Development Organization, will construct and operate the facilities which are to be provided for common use to researchers both at home and abroad. In 1991, the Marine Organisms Utilization Technology Research Center for Mining and Industry Co., Ltd. started operation in this

Table 3-3-12. Summary of the Law for Facilitating Governmental Research Exchange

Item	Legal system before enforcement of this law	Special measures under this law
Employment of foreigners (Article 3)	* In principle, foreigners can be appointed as researchers, but their work is limited to testing and research.	* Foreigners can be appointed even as research division managers or research section managers.
Participation in research meetings (Article 4)	* As part of official duties (business trip, outside duties) or on holidays.	* As the third method, one can be released from the obligation to carry out one's duties.
Improvement of retirement allowances when suspended from office (Article 5)	* For leave to devote oneself to research at a school, institute, hospital and other public facilities (research leave), half of the period is used for calculating the retirement allowance according to the length of service.	* For leave necessary for carrying out research entrusted, by or joint research with, a national research institute, 100% of the period is credited.
Improvement of patent handling, etc. related to research institutes. (Article 6)	* National research institutes apply for patents, etc.	* Part of the patent rights can be assigned to a trustee who has borne the cost.
Use of patents, etc. related to international joint research free of charge or at low cost (Article 7)	* It is often requested to use patents, etc. of national institutes free of charge or at low cost in case of international joint research. To realize this, some legal basis should exist. Basic laws usually are available in limited cases.	* For joint research with foreign governments, foreign public groups or international institutes, such convenience is provided.
Waiver of compensation claims relating to international joint research (Article 8)	* It is often requested in international joint research to waive governmental compensation claims. To realize this, some legal basis should exist. But when no legal basis exists, claims cannot be waived.	* Same as in the above case.
Use of National testing and research institutions at little expense (Article 9)	* To permit the use of national property at little expense, some legal basis should exist, which is usually available only in limited cases.	* When a person, who is closely related to the research activities of a national institute which manages research installations and is involved in research advantageous to the above research, wished to disclose the results of his research, such shall be permitted.
What should be considered: (Article 10)		* To conduct international research exchange using special measures under this law, special attention shall be paid to fulfilling the obligation to execute treaties and other international promises and to maintain international peace and security.

project and the following enterprises began to operate partially: Ion Engineering Center Co., Ltd., Underground Nongravity Experiment Center Co., Ltd., Super-high-Temperature Materials Research Center Co., Ltd. and Laser Application Engineering Center Co., Ltd.

3.3.3.4. Promotion of Research Exchange

In recent years, scientific R&D have become increasingly advanced, complex and interdisciplinary in nature. To promote creativity in science and technology, Japan must commit itself to developing the organizational infrastructure for R&D that will allow for the free movement of researchers, as well as for dissemination of research findings and materials. This will ensure that the limited resources that can be made available for research are used as efficiently and effectively as possible.

In the past, the legal restrictions placed on civil servants and the strict asset control measures applied by the government made it difficult for researchers to interact and cooperate with the private sector, or other countries. The government has moved to remove impediments in the relevant laws by enacting *The Law for Facilitating Governmental Research Exchange* in November 1986 (Table 3-3-12). In March 1987, the cabinet approved *The Fundamental Policy for the administration of institutions to promote governmental research exchange between industry, universities and foreign countries* to help ease the implementation of the aforementioned law.

In FY1990, the Steering Committee of the Liaison Council on the Promotion of Research Exchange, with a membership of division directors at various ministries and agencies, met to follow up on the implementation of related systems. The committee also investigates the points to be revised in the current *Law for Facilitating Governmental Research Exchange* and the matters requiring new measures for promoting research exchanges.

3.3.3.5. Distribution of Scientific and Technological Information

Scientific and technological information is the result of the distillation of highly specialized knowledge obtained through R&D and supported by major financial investments. Scientific and technological information also is a major component of the infrastructure for promoting R&D.

As science and technology develops, the annual volume of research information continues to increase, making it difficult for researchers to access needed information swiftly. It is, therefore, increasingly important to gather and organize information into easily referenced systems, which can then be supplied on demand to individual users in the requested format.

3.3.3.5.1. Basic Policies for the Promotion of Scientific and Technological Information-related Activities

The CST Recommendation pursuant to Inquiry No. 4, *Basic Guidelines regarding the Distribution of Scientific and Technological Information,* submitted in October 1969, makes the basis for the promotion of scientific and technological information-related activities using the concept of a National Information System for Science and Technology (NIST).

In December 1989, in its Recommendation pursuant to Inquiry No. 16, *Basic Guidelines for Managing the Infrastructure for Science and Technology Promotion,* the CST outlined the importance of a healthy promotional infrastructure, including scientific and technological information. To facilitate this, the CST proposed implementation of the following measures.

- Reinforcement of the information distribution infrastructure with an emphasis on improving the quality of information and ensuring easy access to information by users
- Further international distribution of

Table 3-3-13. Distribution of science and technology information measures in FY 1991

Ministry or agency	Organization	Activity
National Diet Library		* Collecting domestic and foreign scientific and technical publications, building indexing databases and supplying information services
Science Council of Japan		* Compilation of data on international cooperative activities of the International Council of Scientific Union (ICSU)
Science and Technology Agency	* Science and Technology Promotion Bureau	* Research concerning construction of self-organizing information base systems for supporting development of creative research and other projects funded by the Special Coordination Funds for Promoting Science and Technology
	* Japan Information Center of Science and Technology (JICST)	* Building and maintaining databases of scientific and technical literature and reference databases, including an English-language database. Providing domestic and overseas information services. * International dissemination of Japanese government publications on science and technology
	* Japan Atomic Energy Research Institute	* Cooperative work on an international system of networks and databases for information on nuclear energy
	* Power Reactor and Nuclear Fuel Development Corporation	* Compilation of information on nuclear fuel resources
	* National Space Development Agency of Japan	* Design and operation of comprehensive system of networks and databases for information on space development
	* Research Development Corporation of Japan	* Compilation of a directory of research on the global environment
Environment Agency	* National Environment Research Institute	* Collecting data on the environment and building databases
	* National Minamata Disease Research Center	* Collecting information and cataloging literature on mercury poisoning
Ministry of Education	* National Center for Science Information Systems (NACSIS)	* R&D, planning, and coordination of systems for scientific information * Establishing networks, building databases, and providing information services * Electronic mail services
	* Scientific Information Systems Development Activities	* Establishment of mainframe computer centers and information-processing centers, computerization of university libraries, establishment of information networks for university use
	* Grant-in Aid for Scientific Research	* Support for primary publication of research findings * Support for databases built by researchers
Ministry of Health and Welfare	* Medical Information Systems Development Activities	* Development and promotion of information systems for medical use * Development of information support systems for public health centers
	* Pharmaceutical Product Safety Investigations	* Collection data on the side effects of pharmaceutical products
	* National Institute of Hygienic Sciences	* Evaluation of the effects of chemical substances on health

(Tab.3-3-13)

Ministry of agency	Organization	Activity
Ministry of Agriculture, Forestry and Fisheries	* Office of the Agriculture, Forestry and Fisheries Research Council	* Management of the Agriculture, Forestry and Fisheries Research Information Center; collection of information and maintenance of databases on genetic resources
Ministry of International Trade and Industry	* Agency of Industrial Science and Technology (AIST)	* Participation in a network for exchange of information on international standards
	* Patent Agency	* Development of a database retrieval system for reference materials used in patent investigations * Building patent information databases
	* Small- and Medium-Enterprise Agency	* Collecting, cataloging and supplying of technical literature relevant to small- and medium-size enterprises
Ministry of Transport	* Maritime Safety Agency	* Operation of the Japan Ocean Data Center
	* Meteorological Agency	* Operating the Global Warming Information Center
Ministry of Posts and Telecommunications	* Communications Research Laboratory	* Operation of the Ionosphere Data Center
Ministry of Labor	* Harmful Substances Investigation	* Investigation of potentially harmful substances and formulation of corrective action
Ministry of Construction	* Building Research Institute	* Establishment of image-processing systems
	* Geographical Survey Institute	* Provision and use of telecommunication networks for survey data results

information and the dissemination of information among regional areas in Japan

- Intensified and broader information collection
- More advanced information dissemination capabilities

3.3.3.5.2. Scientific and Technological Information Activities in Japan

The following sections summarize science and technology information activities in Japan. Table 3-3-13 lists scientific and technological information distribution activities by government ministry and agency.

3.3.3.5.2.1. Primary Information Services

Libraries and several other information service organizations make primary literature available for reading, photocopying or loan. According to the National Diet Library (NDL) Law, all unclassified publications issued in Japan are to be deposited in NDL. The library has created a database of its collection and has made this available for use on-line.

The Ministry of Education's National Center for Science Information Systems (NACSIS), in cooperation with national and local governments and private universities and colleges, has created a database that catalogs the location of books and magazines available in university libraries nationwide and made this information available for referencing.

3.3.3.5.2.2. Secondary Information Services

The use of computers to edit and build databases allows researchers to search large volumes of data quickly, accurately and with relative ease.

Recently, the creation and utilization of databases in science and technology fields has increased sharply worldwide, a typical example being the text databases used to store the contents of large numbers of academic theses. However, there is also an increasing demand for factual databases that store numerical and image data.

The Japan Information Center of Science and

Technology (JICST) builds comprehensive text databases, inputting approximately 640,000 science and technology documents annually. JICST provides access to these on-line. The center also maintains reference databases for information such as that found in dictionaries of chemical compounds.

NACSIS creates databases for use in scientific research, providing this information nationwide over a scientific information network that links national, local governments' and private universities and related organizations.

The Japan Patent Information Organization (JAPIO) has created a database of patent information that is available on-line.

3.3.3.5.2.3. Clearing Services

Clearing services provide information on specific research topics. JICST supplies on-line information on a variety of research topics from public research institutes.

NACSIS has created an on-line database containing abstracts of research funded by Grant-in-Aid for Scientific Research.

3.3.3.5.2.4. International Dissemination of Scientific and Technological Information

Overseas demand for Japanese scientific and technological information has increased as the nation's science and technology has progressed.

In November 1987, the Science and Technology Network International(STN International) was established by JICST, the Chemical Abstracts Service(CAS) of the United States and the FIZ Karlsruhe, Specialized Information Center of Germany to make Japanese science and technology information available worldwide.

NACSIS also has been disseminating internationally Japanese scientific information. In January 1989, the Center established a link with the United States National Science Foundation (NSF). This was followed by establishing ties with the United States Library of Congress(LC) in the same year and with the British Library(BL) in 1990.

Since FY1990, JICST has been disseminating government documents in science and technology fields which had hitherto been difficult for overseas researchers to obtain. In April 1991, JICST held an explanatory meeting on Japanese scientific and technological information in Washington.

3.3.3.5.2.5. Advancement of R&D Related to Scientific and Technological Information

The advancement of R&D related to scientific and technological information has been furthered through the program, *Research on a Knowledge-based System to Support the Design of Chemical Substances,* which began in FY1986 and was completed in FY1990. The goal of this program was the establishment of a large-scale knowledge-based system to facilitate the design of new or application-level chemical substances.

Another important program is titled *Investigations for Building a Self-organizing Information-based System to Assist Creative R&D,* which began in FY1990. Both of these programs are being financed using the Special Coordination Funds for Promoting Science and Technology.

Further, JICST has been working on *The Full-text Database Prototype Development* program to implement a practical full-text Japanese language database.

3.3.3.6. Science and Technology Promotion at Regional Levels

Both the CST, in its Recommendation pursuant to Inquiry No. 11, submitted in November 1984, and the Cabinet in its *Fourth Nationwide Comprehensive Development Plan,* approved in June 1987, identified the strengthening of regional R&D capability as a strategic issue.

Given this, more and more of Japan's regional areas have been attempting to improve their R&D capabilities over the last few years. Kanagawa, Toyama, Hyogo, Shizuoka and other

prefectures held councils and meetings deliberating measures for development of science and technology. Kanagawa, Saitama, Iwate and other prefectures formulated general principles and guidelines for science and technology policy. Many regions across the country have begun actively developing science and technology.

Hitherto, R&D advances in regional areas have been centered on the work of public research organizations. More recently, with improvement in the technological development capability of regional industries, many local governments are considering reorganization and rearrangement of public research institutes.

New measures for development of science and technology at the local government level have been appearing. These include the determination of a science city concept in the region and the establishment of a public corporation as a core organization for promoting comprehensively scientific and technological development.

Here, we will outline various measures taken by the central government to develop science and technology in the regions (Table 3-3-14).

3.3.3.6.1. Regional Science and Technology Promotion Conference

In order to promote of regional science and technology, the Science and Technology Agency has divided the country into eight geographic

Table 3-3-14. Regional science and technology promotion programs

Ministry or agency/organization	Program	Overview
Science and Technology Agency		
* Science and Technology Promotion Bureau	* Activities for promoting regional research exchanges (regional hightech networks)	* Establishment of regional research information networks and implementation of the Research Development Corporation of Japan's *New Technology Development Program*
	* Regional floating research	* Excellent researchers in and out of the region will be brought together into research institutes of the region and they will conduct basic and pioneering research exploiting the features of the region.
* Research and Development Bureau	* Special Institution for Joint Research by Government and Private Enterprises (by regional area)	* Special joint research programs between public research institutes and private enterprises
* Japan Marine Science and Technology Center	* Regionally-centered joint R&D projects	* R&D for on-site experiments aimed at maximum utilization of the nation's coastlines and conducted with the cooperation of regional governments
Ministry of Agriculture, Forestry and Fisheries		
* Office of the Agricultural, Forestry and Fisheries Research Council	* Regional promotion of biotechnology R&D	* Joint research by the ministry's agricultural experimental stations/facilities and public research institutes in biotechnology
	* Joint research with the ministry's agricultural experimental stations	* Joint research by the national research institutes and public research institutes in regionally important fields at the request of prefectural agricultural experimental stations
Ministry of International Trade and Industry		
* Agency of Industrial Science and Technology	* Measures for Regional Technology Development	* Joint R&D by the research organizations of the Agency of Industrial Science and Technology, public research institutes and private enterprise that addresses the specific needs of regional areas

units. In each of these it sponsors conferences on science and technology which are attended by representatives of various science and technology related organizations, private enterprises, academic institutions, and other interested bodies in the region. The aim of these conferences is twofold. On the one hand, it is to formulate mutually achievable goals for the future and to contribute to the establishment of an infrastructure for the advancement of science and technology in each region. On the other, it is to achieve a mutual understanding of national and regional perspectives on science and technology, and to investigate the various problems related to the promotion of science and technology in each geographic area.

3.3.3.6.2. Activities for Promoting Regional Research Communications (Regional High-technology Networks)

Since FY1988, the Science and Technology Agency has been establishing *Regional High-technology Networks* to facilitate research-related communications, information exchange, and new technology development within a given region, or between a region and Tsukuba Science City. As of the end of FY1990, high-technology networks have been set up and are in use to promote advanced regional R&D through research-related communications in Oita, Shizuoka and Toyama/Ishikawa prefectures, the Tohoku region, and in Kyoto/Osaka/Nara prefectures.

3.3.3.6.3. Regional Floating Research Program

The Science and Technology Agency has been implementing since 1990 *The Regional Floating Research Program.* Under this program excellent researchers in and out of the relevant region are brought together in research institutes in the region. They conduct basic and leading research which contributes to the enhancement of Japan's scientific and technological levels, as well as incorporates features of the region. The Special Coordination Funds for Promoting Science and Technology support this program.

The research is being promoted actively by bringing together investigators from national research institutes, universities, public research institutes and private firms under the guidance of the region's central organizers who lead the promotion of research activities. In FY1990, these research activities began in Yamagata, Fukuoka, and Okinawa Prefectures.

3.3.3.6.4. R&D Projects for the Regionally Important Technology Program

Since FY1982, the Ministry of International Trade and Industry has been implementing its *Measures for Regional Technology Development* program to address specific R&D issues arising from the needs of regional areas. These programs conduct joint R&D through the cooperative efforts of the regional research institutes of the Agency of Industrial Science and Technology, the public experimental laboratories and private enterprise. At present these cooperative efforts are underway in seven regions--Hokkaido, Tohoku, Chubu, Kinki, Chugoku, Shikoku and Kyushu. Regional technology development is being stimulated through the combined input of industry, academic institutions and the above-mentioned government and regional bodies.

3.3.3.6.5. Main and Regional R&D Center Infrastructure

The Fourth Nationwide Comprehensive Development Plan calls for the development of main cultural, academic and research centers at Tsukuba and in the area bounded by the cities of Kyoto, Osaka and Nara. The Plan also calls for the development of science cities that maintain distinctive regional characteristics and the linking of these cities to establish a network of R&D.

3.3.3.6.5.1. Tsukuba Science City

Tsukuba Science City is a center of advanced research and higher education that contributes to the balanced development of the Tokyo Metropolitan Area. Construction of new facilities at Tsukuba Science City is continuing as part of a national effort to meet current demands in science, scientific research and higher education.

At present, facilities for 47 national experimental laboratories, research facilities and educational organizations are nearing completion or have already begun operation. Private research institutes also are located in the city.

The infrastructure of Tsukuba Science City is being expanded and enriched and many measures are being implemented that will make the city a major national and international R&D center.

3.3.3.6.5.2. Kansai Science City

The Kansai Science City Construction Promotion Act, enacted in June 1987, serves as the basis for work in progress to establish the infrastructure for Kansai Science City. The city is being set up with the objective of serving as a major center that can draw on the rich cultural, academic and scientific traditions of *The Kinki* region to become a creative, international, academic and interdisciplinary center for culture and research.

3.3.3.7. Promotion of Research in the Private Sector

3.3.3.7.1. "Cooperative Development of Industrial Technology" and "Coordination for Licensing"

The long-term monetary investment required to develop new technologies and the associated risks have increased year by year as technologies have grown more advanced, larger in scale, and more complex.

The Research Development Corporation of Japan (JRDC) surveys and compiles experimental research results at universities, national research institutes and other research organizations to dig out promising results, and through "Cooperative Development of Industrial Technology" contacts with companies to develop those results which otherwise would be difficult to be commercialized. In this way JRDC actively promotes the commercialization of new technologies. JRDC also makes available the developed technology so that it can be used by companies in the private sector.

For new technologies which can be developed on a commercial basis with relatively small risks, JRDC promotes their transfer to companies through "Coordination for Licensing". JRDC promotes technology transfer to foreign countries by publishing an English-language magazine about new technologies possible for licensing overseas.

By the end of FY1990, 251 "Cooperative Development of Industrial Technology" projects were successful and 435 experimental research results were transferred to 703 companies.

3.3.3.7.2. Promotion through Preferential Taxation and Financial Provisions

The government is promoting the smooth development of research activities and the advancement of new technology through preferential taxation and financial provisions for private-sector research expenditures.

Tax benefits within the national taxation system include *The Tax Deduction on Experimental and Research Expense Increments*, instituted in FY1967. This allows corporations to deduct from their tax assessment 20% of the incremental increase over their previous highest expenditure for research. This program has been a major factor in encouraging the expansion of private-sector research activities based on independent and innovative efforts.

Another preferential tax measure, adopted in FY1985, is *The Tax Program for Promoting R&D of Basic Technologies* which exempts businesses from 7% of the acquisition cost of

assets, such as equipment and facilities, purchased for the purpose of conducting R&D in the basic technology areas.

Another measure of this type adopted in the same year is *The Tax Deduction for Strengthening the Technological Foundation of Small- and Medium-scale Enterprises.* This program, which may be selected as an alternative to *The Tax Deduction on Experimental and Research Expense Increments,* allows small- and medium-sized enterprises to deduct from their assessment a maximum of 6% of their overall research expenditures every tax year.

Similar preferential tax provisions to *The Tax Program for Promoting R&D of Basic Technologies* and *The Tax Deduction for Strengthening the Technological Foundation of Small- and Medium-scale Enterprises* were adopted as special measures in local taxation structures and provide for reductions in the standard taxation determined by the corporate residential tax rate. See also Table 3-3-15 for a summary of the main tax provisions for promoting science and technology.

There are also a number of financial provisions designed to help raise the nation's level of technological development through the provision of low-interest loans. These include the Japan Development Bank's *Domestic Technology Promotion Funding System* (the Industrial Technology Promotion Funding System and the Information Systems Promotion Funding System).

The Technology Promotion Funding System provided loans totaling 227.5 billion yen during FY1990, which not only helped finance the improvement of Japan's technological development, but also the development of the public information infrastructure.

Further, the Medium- and Small-scale Enterprise Finance Corporation has established *The New Business, New Technology Promotion Funding System* to stimulate new technology development and further technological advancement at small- and medium-scale enterprises.

3.3.4. International Exchange of Science and Technology

3.3.4.1. Bilateral Cooperation

3.3.4.1.1. Cooperation with Industrialized Nations

Cooperation between Japan and other industrialized nations is conducted mainly on the basis of bilateral cooperation agreements. Cooperative goals include solutions to problems common to the industrialized nations related to natural resources development, energy development, nuclear energy, space development, ocean development, biotechnology and environmental protection.

Japan and the United States have been cooperating in non-energy areas since the Japan-U.S. Science and Technology Cooperation Agreement was concluded in May 1980. This was superseded in June 1988 by the new Japan-U.S. Science and Technology Cooperation Agreement to reflect changes in the conditions surrounding Japan-U.S. science and technology relations.

So far, an active exchange of opinions has taken place on a variety of levels, including two meetings of the Joint High-Level Committee chaired at the ministerial level, four meetings of the Joint Working-Level Committee that laid the groundwork for the Joint High-Level Committee, and three meetings of the Joint High-Level Advisory Panel of experts from the two countries. In addition, two Task Forces met to investigate issues of the participation of researchers in R&D and access to scientific and technological information of each country.

At the second Joint High-Level Committee in May 1990, 17 new joint research projects were agreed to with the intent of continuing steady progress in bilateral cooperation. The Committee also debated a wide variety of issues, including ways to promote basic research, to address global environmental problems, and to carry out

Table 3-3-15. Major preferential tax measures for science and technology promotion (as of April, 1991)

Item	Purpose	Description	Applicable law	Date of enactment/validity
Tax Deduction on Experimental and Research Expense Increments	Promotion of technological development	1. Corporations can deduct 20% of the incremental increase in research expenditures from their tax assessment (with an upper limit of 10% of their tax assessment) provided that the research expenditures for the applicable tax year (the amount debited against income) exceed the maximum annual research expenditure for all tax years falling between the standard tax year (defined below) and the immediately preceding business tax year. In addition, corporations may treat 20% of investments in approved experimental research companies as a research expenditure. Notes Applicable tax years: All business years starting between June 1, 1967 and March 31, 1993 Standard tax years: Business tax years immediately preceding the business tax year in which January 1, 1967 falls 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 10, Item 1 (personal income tax), Article 42-4, Items 1,4 (corporate income tax)	Enacted in *FY* 1967, effective through *FY*1992
Tax Program for Promoting the R&D of Basic Technologies	Promotion of technological development	[National taxes] 1. In addition to the current *Deductions on Experimental and Research Expense Increments*, corporations may deduct from their tax assessment 7% of the acquisition cost of assets to be used for R&D of basic technologies, including specialty materials, advanced electronics technology, telecommunications technology, and space-development, with an upper limit of 15% of their tax assessment. 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 10, Item 2 (personal income tax), Article 42-4, Item 2 (corporate income tax)	Enacted in *FY*1985, effective through *FY*1992
		[local taxes] 3. Corporations may deduct 7% of the acquisition cost of assets to be used for R&D of basic technologies from the standard taxation determined by corporate residential tax rate, with an upper limit of 15% of the standard taxation.	Local Taxation Law, Supplementary Provisions, Article 8, Item 1	Enacted in *FY*1985, effective through *FY*1992
Tax Program for Strengthening the Technological Foundation of Small- and Medium-scale Enterprises	Promotion of technological development	[National taxes] 1. As an alternative to taking the *Deductions on Experimental Research Expense Increments*, small- and medium-scale enterprises paying corporate income taxes may choose to take a tax deduction of 6% of their research expenditures, with an upper limit of 15% of their tax assessment. In addition, they may treat 20% of investments in approved experimental research companies as a research expenditure. 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 10, Item 3 (personal income tax), Article 42-4, Item 3,4 (corporate income tax)	Enacted in *FY*1985, effective through *FY*1992

(Tab. 3-3-15)

Item	Purpose	Description	Applicable law	Date of enactment/validity
Tax Deduction on Experimental and Research Expense Increments	Promotion of technological development	[local taxes] 3. Small- and medium-scale enterprises opting for the 6% deduction above may deduct this amount from the standard taxation determined by the corporate residential tax rate, with an upper limit of 15% of the standard taxation.	Local Taxation Law, Supplementary Provisions, Article 8, Item 2	Enacted in *FY*1985, effective through *FY*1992
Special Exemption of Income Associated with Overseas Transactions Related to Technology Transfers	Promotion of diverse types of overseas transactions and the promotion of technology transfers and domestic technology development	1. Corporations receiving income from overseas transactions related to technology transfer are exempt from a portion of this income (not to exceed 40% of applicable tax year's income) as a debit against taxable income. Specifically, they are exempt from * 12% of income from the supply or transfer of industrial property rights (excluding trademark rights) and know-how * 16% of income from consulting activities 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 21 (personal income tax), Article 58 (corporate income tax)	Enacted in *FY*1964, effective through *FY*1991
Exemption of Donations and Contributions				
1. Donations to specified public-service promotion corporations. See note.	Promotion of education, science and technology	1. Corporations Corporations may enter the amount of their donations as a separate item of debits-against-income and distinct from general donations. The upper limit is the same as that for general donations.	Corporate Taxation Law, Article 37 Item 3	Enacted in *FY*1961
		2. Individuals The income tax exemption corresponding to each donation to a specified public benefit corporation is calculated as the amount of the donation less 10,000 yen. The total amount of donations used in these calculations may not exceed 25% of income.	Personal Income Taxation Law, Article 78, Item 1,2	Tax exemption method enacted in *FY*1962 and revised in *FY*1967
2. Contributions to specified public-service trusts	Promotion of education, science and technology	Corporations and individuals can apply exemptions for donations to approved public-service trusts by including the amounts of these donations in the totals for donations to specified public-service promotion corporations. Corporations should then calculate debits against income, while individuals calculate income tax exemption. Note Approved public-service promotion corporations include corporations whose main purpose is research in science and technology, and certain public-service trusts whose purpose is to aid research in science and technology.		Enacted in October 1987
3. Specific donations	Promotion of education, science and technology	Corporations may deduct the entire amount of donations allocated for urgently needed education or science promotion expenditures in debits against income. Individuals may treat these donations as donations to specified public-service promotion corporations as described above.	Corporate Taxation Law, Article 37,, Item 3, Income Taxation Law, Article 78, Items 1,2	Enacted in *FY*1960

(Tab. 3-3-15)

Item	Purpose	Description	Applicable law	Date of enactment/validity
Measure for Exceptional Treatment of Fixed Asset Acquisitions for Experimental Research by the Mining and Industrial Technology Research Cooperatives	Promotion of technological R&D	Members of the Mining and Manufacturing Technological Research Association may apply special depreciation to payments levied by the Association to acquire fixed assets for experimental research.	Special Taxation Measures Law, Article 18 (personal income tax), Article 52 (corporate income tax)	Enacted in *FY*1961, effective through *FY*1992
		The Mining and Industrial Technology Research Cooperatives may enter the value of fixed assets acquired for experimental research by levy on members in its account books as 1 yen.	Special Taxation Measures law, Article 66-10	Enacted in *FY*1961, effective through *FY*1992
Measure for Tax Exemptions on Research Assets of Scientific Research Corporations	Promotion of science and technology	Assets provided to corporations established under Civil Law Article 34 for the purpose of scientific research are exempt from the real estate acquisition tax, fixed assets tax, special land holding tax and urban planning tax on investments used directly for that research.	Local Taxation Law, Article 73-4, Item 1, Article 348, Article 586, Article 702-2	Fixed asset tax enacted in *FY*1951; real estate acquisition tax, in *FY*1954; urban planning tax, in *FY*1956; special land holding tax in *FY*1973
Fixed Asset Tax Reduction Measure for Machines and Equipment for Research acquired by the Mining and Industrial Technology Research Cooperatives	Promotion of technological development	The standard of assessment for the machinery and equipment fixed assets approved under the regulations of the Mining and Industrial Technology Research Cooperatives Law, Article 14 and additionally acquired between April 1, 1989 and March 31, 1991 is valued at four-fifth of the standard value for period of three years from the year in which tax was first levied on the asset.	Local Taxation Law, Supplementary Provisions, Article 15, Item 26	Enacted in *FY*1962, applicable to the first three years after acquisition

international cooperation in large-scale projects.

As a result of discussions in the 4th Joint Working-Level Committee held in July 1991, the number of cooperative projects totalled 50.

In June 1990, for about 2 months, *The Summer Institute Program* began to accept graduate students of the U.S. into national research institutes, etc. in Japan.

The Japan-U.S. Energy R&D Agreement was revised in February 1990, primarily to keep up with the changes made in the Japan-U.S. Science and Technology Cooperation Agreement.

Japan-U.S. cooperative activities in the field of space development have been based on the Japan- U.S. Space Agreement concluded in July 1969, and on the activities of the Senior Standing Liaison Group, established in July 1979 on the basis of an agreement between Japan's Space Activities Commission and the National Aeronautics and Space Administration of the United States.

Further, cooperation in a wide range of science and technology fields is being encouraged through the Japan-U.S. Committee on Scientific Cooperation, the Japan-U.S. Conference on Development and Utilization of Natural

Resources, and the Japan-U.S. Cooperation Agreement on Nuclear Energy.

In June 1991, the new Japan-France Science and Technology Cooperation Agreement, a revision of the old agreement concluded in 1974, was concluded in order to advance further the scientific and technological cooperation between both countries. The agreement was revised because of recent progress in science and technology made in both countries.

Cooperation with Canada was initiated through the Japan-Canada Science and Technology consultation that began in 1972. This was superseded in May 1986 by the Japan-Canada Science and Technology Cooperation Agreement.

Pursuant to the agreement, which has the goal of increasing science and technology cooperation between the two countries, three joint committees and one special meeting were held, with resultant cooperation in a broad range of fields.

In May 1989, experts from the two countries compiled the Japan-Canada Complementarity Study to explore the priorities for future scientific and technological cooperation. Eighteen medium-scale promising fields for joint research were chosen, and based on these, researchers from both countries have exchanged views at workshops in three research fields.

Japan and Germany cooperate in the areas of nuclear energy, life sciences, ocean science and technology, etc. based on the Japan-Germany Science and Technology Cooperation Agreement concluded in October 1974 between Japan and West Germany. After the integration of East and West Germanies in October 1990, the Agreement was confirmed to be effective under the entire territory of integrated Germany. Progress in cooperation with integrated Germany is expected in the future.

Japan has concluded science and technology cooperation agreements with other industrialized countries; e.g., Italy and Australia; and cooperative activities in a variety of fields are underway based on these agreements. Cooperation with other countries also is underway through working-level staff activities, including Anglo-Japanese Science and Technology Cooperation Talks between Japanese and UK officials and the Japanese-Finish Meeting on Cooperation in Science and Technology, as well as through Trade and Economic Consultations with Sweden and Norway.

The Japan-EC Ministerial Meeting and the Japan-EC High Level Consultation have also been taking up science and technology cooperation issues. In addition to the above cooperative activities, there exist various cooperative frameworks in science and technology.

3.3.4.1.2. Cooperation with Developing Nations

Japan is cooperating with the Republic of Korea, the People's Republic of China, Indonesia, Brazil and India in a variety of fields on the basis of science and technology agreements.

In November 1970, the nations of Asia and the Pacific Rim agreed to establish the Association for Science Cooperation in Asia (ASCA). ASCA has held eleven plenary meetings since then, with the objective of heightening scientific and technological cooperation within the region.

Under the auspices of the Association, Asian nations have exchanged information on science and technology policies and R&D plans for the region, clarified areas of common concern, and explored measures for advancing cooperation in science and technology projects.

Japan has sent representatives to every plenary meeting and has conducted annual seminars on specific subjects of major interest to ASCA member nations. In January 1991, a seminar was held on addressing global environmental problems by using earth observation satellites and a seminar on earthquake prediction and prevention of earthquake disasters was held in March 1991.

In 1980, Japan also initiated the ASCA Cooperative Program on Scientific and Technological Information under which Japan has been supplying science and technology information to ASCA nations.

3.3.4.1.3. Cooperation with the U.S.S.R. and Eastern European Nations

Cooperation with the U.S.S.R. has been promoted based on the Japan-U.S.S.R. Agreement on Cooperation in Science and Technology, concluded in October 1973. Under this agreement, seven joint committees have been formed and cooperation has been promoted in the form of exchange of information and researchers, holding seminars, etc. in the fields of nuclear fusion, agriculture, etc.

In addition to the above, investigator exchanges have increased under the Japan-U.S.S.R. Researcher Exchange Arrangement.

Japan has been cooperating with Eastern European nations through exchange of researchers, etc. according to science and technology cooperation agreements with Poland and Yugoslavia and science and technology cooperation arrangements with Romania, Bulgaria, Czechoslovakia and Hungary.

3.3.4.2. Multilateral Cooperation

3.3.4.2.1. International Cooperation Based on the Economic Summit of the Heads of State or Government of Seven Major Industrial Nations and the President of the Commission of the European Communities

The leaders of the industrialized nations have been discussing science and technology issues at Summits every year since French President Mitterand first raised the subject at the 8th Summit at Versailles in June 1982.

The Arch Summit initiated cooperation in expanding global observation and monitoring activities in response to the problem of global warming, an issue that has become of increasing concern in recent years. In July 1990, the nations at the Houston Summit supported implementation of scientific and economic surveys and analyses and development of better data network infrastructure to address the global warming phenomenon.

3.3.4.2.2. Cooperation with the United Nations

United Nations committees and organizations are addressing important issues related to natural resources, energy, food, climate, environment and natural disasters, since these problems require solutions derived from a global perspective.

They are making an effort to contribute to a long-term solution of the North-South problem by strengthening the science and technology capabilities of developing nations as these nations suffer the most from the above-mentioned problems.

3.3.4.2.3. Cooperation within the Organization for Economic Cooperation and Development

Cooperation in science and technology related activities within the Organization for Economic Cooperation and Development (OECD) framework has been conducted through the Committee for Scientific and Technological Policy (CSTP), Committee for Information, Computer and Communications Policy, Industry Committee, Environment Committee, Nuclear Energy Agency (NEA), International Energy Agency (IEA). Activities include exchanging opinions, useful experiences, information and personnel, compiling of statistical information and being involved in joint research projects.

Following the 1987 OECD Ministerial Council communiqué recommending a more in-depth analysis of technology related issues, the Technology and Economy Program (TEP) started as a three-year project within OECD in 1988. This project aimed to acquire a comprehensive picture of the influence of science and technology on the world's is

socioeconomic situation. Several symposia were held in many countries, one of which is a symposium on the theme of Technoglobalism held in Tokyo in March 1990. At the meeting held in February 1991 in Montreal, the results of the TEP were synthesized into a report which was presented to the Secretary-General of OECD. The main purport of this report was incorporated in the announcement of OECD's policy on technology and economy in its Ministerial Council in June 1991.

3.3.4.2.4. Promotion of the Human Frontier Science Program

The Human Frontier Science Program (HFSP) is an international program which promotes, through international cooperation, basic research focused on the elucidation of the sophisticated and complex mechanisms of living organisms. The Japanese government proposed the program at the Venice Economic Summit in June 1987, as a means for the government to contribute to the development of international science and technology in a manner appropriate to its economic standing. The HFSP also can help to increase international public assets through the promotion of basic research and to make the research results available to all humankind.

The program and the Japanese initiative behind it have been lauded by the Economic Summit member countries. In October 1989, the organization for the implementation of the HFSP, the International HFSP Organization (HFSPO), was established in Strasbourg, France.

The Program offers support for the following activities.

- Research grants: Subsidies for international joint research teams
- Long-term and short-term fellowships: Travel and accommodation subsidies for researchers who wish to do research in foreign countries
- Workshops: Subsidies for international workshops

The fields eligible for support fall into two basic research areas--the elucidation of brain functions and the elucidation of biological functions through a molecular level approach. On the basis of recommendations by the International Scientific Committee, consisting of eminent scientists, these research areas were agreed to by the countries concerned.

The Declaration of the Houston Economic Summit in July 1990 notes with satisfaction the successful launching of the HFSP and expresses the hope that it will make positive contributions to benefit of all mankind.

The HFSPO reported in March 1991 that 232 researchers from 22 countries had been selected as the award recipients for the second fiscal year.

3.3.4.3. Promoting International Research Exchange

For many years, Japan has been cooperating with other countries in a wide range of fields within the framework of bilateral and multilateral scientific and technological cooperation agreements. However, Japan needs to extend its international research exchange to meet worldwide expectations regarding the nation's role and to stimulate Japanese science and technology within the context of international cooperation.

Since FY1987, the government has carried out the bilateral international joint research within the framework of bilateral science and technology cooperation agreements, by using the Special Coordination Funds for Promoting Science and Technology. To promote effectively international research exchanges in important areas of cooperation in view of policy issues related to science and technology cooperation agreements, etc., the government started in 1991 the International Workshops Support Program to hold international workshops in which researchers may exchange opinions directly.

In FY1988, the following three programs were started to increase the acceptance of researchers from overseas at Japanese R&D organizations.

- The Science and Technology Agency Fellowship Program, which provides for the acceptance of young researchers from overseas at the national research institutes
- The Japan Society for the Promotion of Science (JSPS) Fellowship for Research in Japan, which provides for the acceptance of overseas researchers at Japanese academic institutions
- The Foreign Researcher Invitation Program of the Agency of Industrial Science and Technology (AIST), which provides for the acceptance of overseas researchers in its research institutes

In October 1989, the Research Development Corporation of Japan (JRDC) started the following new programs to expand international research exchanges.

- Administration of the Science and Technology Agency Fellowship Program
- The Support Program, which includes operating dormitory facilities and providing practical assistance for overseas researchers and their families
- The Research Information Program, which disseminates scientific and technological information required to increase the exchange
- International Joint Research Program, which initiates joint research with overseas research organizations.

In addition, other ministries and agencies have taken measures to promote international research cooperation.

3.3.5. A Chronology of Principal R&D Programs

In the 1960s, Japan began to recognize the importance of independent technology development, while Japan had by then proceeded actively with the introduction of foreign technology from the U.S. and Europe. A number of big science projects, including nuclear energy, space research and similar programs, were launched during this period.

In FY1966, the Ministry of International Trade and Industry initiated the Large-scale Project Program dealing with leading large-scale industrial technologies, urgently needed for national economic development. Under this program, MITI would bear the substantial costs (investments, long-term commitments and large financial risks) of such projects that private enterprise could not independently sustain. The Ministry of International Trade and Industry carries out this program systematically and effectively in close cooperation with the national research institutes, private industry and academic institutions.

Japan's level of science and technology rose and, accordingly, policy makers began to recognize a change in the focus from learning abroad to active research and development at home. Government policies reflected the increased emphasis placed on basic research or creative research that would provide the environment for the development of new technologies from the very beginning of research.

The Special Coordination Funds for Promoting Science and Technology were first appropriated in FY1981, superseding the previous Special Coordination Funds for Promoting Research. In accordance with the policy set forth by the CST, the funds are intended to support comprehensive coordination of R&D promotion. For example, the funds are used for comprehensive R&D which cuts across the boundaries of existing research organizations. By FY1991, the budget for the Funds had reached 10.5 billion yen.

The funds are administered on the basis of the following six guiding principles.

- Promoting advanced and basic/generic research
- Promoting R&D requiring cooperation among several research institutes
- Strengthening organic ties among industry, the government and academia
- Promoting international collaborative

research projects
- Responding flexibly to urgent research needs
- Conducting research evaluation, as well as investigation and analysis of research and development

For Japan to establish itself as a mature science and technology-based nation, it needs to discover the scientific and technological seeds that become the starting points for the original development of innovative new technologies.

In FY1981, this consideration led the Research Development Corporation of Japan to set up the Exploratory Research for Advanced Technology (ERATO) Program to provide for comprehensive research promotion organized around the most creative people. This is accomplished by appointing distinguished scientists as overall managers with administrative authority over research activities within a designated area of research in a humanistic system which utilizes creativity. It also provides for the procurement of researchers from industry, government, academia and overseas.

Currently, 16 projects are underway with budgets totaling 5.7 billion yen in FY1991. Each project has a limited duration of five years and involves approximately 20 researchers.

The Ministry of International Trade and Industry initiated the Research and Development Program on Basic Technologies for Future Industries in FY1981. This program is conducted cooperatively with industry, academia and the government working together in five specialized R&D fields superconductivity, specialty materials, biotechnology, new functional chips and software. Research themes to be chosen should have shown, either theoretically or experimentally, the potential to be developed as innovative industrial technologies.

The Institute of Physical and Chemical Research initiated the Frontier Research Program in FY1986. This internationally open program brings together researchers in many fields outside the framework of existing research organizations. The program aims at developing new knowledge that will become the foundation for technological innovations in the next century.

At present, the project has four active research groups and has a budget of 2.7 billion yen in FY1991.

Since FY1988, the Ministry of Posts and Telecommunications has been conducting Research on the Frontier of Telecommunications. The program consists of basic and leading R&D that incur high financial risks and long-term commitments far beyond the capacity of the private-sector.

In FY1979, the Ministry of Health and Welfare established the Research Grant for Health Sciences to promote research in the areas of health, medical care, sanitation, etc.

Further, the Ministry of Construction has been implementing since 1972 its Comprehensive Technological Development Project for those issues of urgent need which cover wide-ranging areas of R&D.

APPENDIX

Appendix

1. Changes in R&D expenditures, etc. in Japan

Fiscal Year \ Item	Gross national product	National income	R&D expenditures	Government-financed R&D expenditures	Defense-related R&D expenditures	A	B	C	D	Number of researchers	Population
	Trillion yen	Trillion yen	100 Million yen	100 Million yen	100 Million yen	%	%	%	%	Persons	10 Thousand persons
1970	75.1520	61.0297	11,953.28	3,014.13	110.65	1.59	1.96	25.2	24.5	172,002	10,372.0
71	82.8063	65.9105	13,459.19	3,690.25	123.05	1.63	2.04	27.4	26.7	194,347	10,514.5
72	96.5391	77.9369	15,867.08	4,320.68	140.96	1.64	2.04	27.2	26.6	198,084	10,759.5
73	116.6792	95.8396	19,808.96	5,226.84	155.75	1.70	2.07	26.4	25.8	226,604	10,910.4
74	138.1558	112.4716	24,213.67	6,410.77	161.56	1.75	2.15	26.5	26.0	238,179	11,057.3
75	152.2094	123.9907	26,218.27	7,207.55	169.49	1.72	2.11	27.5	27.0	255,202	11,194.0
76	171.1525	140.3972	29,413.73	8,003.86	188.25	1.72	2.10	27.2	26.7	260,250	11,309.4
77	190.0348	155.7032	32,335.43	8,861.15	218.26	1.70	2.08	27.4	26.9	271,956	11,416.5
78	208.7809	171.7785	35,699.53	9,995.02	242.72	1.71	2.08	28.0	27.5	273,102	11,519.0
79	225.4018	182.2066	40,636.27	11,138.22	276.49	1.80	2.23	27.4	26.9	281,920	11,615.5
80	245.3600	199.5902	46,837.68	12,095.57	295.99	1.91	2.35	25.8	25.4	302,585	11,706.0
81	260.3343	209.7489	53,639.86	13,403.20	325.73	2.06	2.56	25.0	24.5	317,487	11,790.2
82	273.4615	219.3918	58,815.39	13,888.12	364.87	2.15	2.68	23.6	23.1	329,728	11,872.8
83	285.9973	230.8057	65,037.37	14,407.17	394.52	2.27	2.82	22.2	21.7	342,237	11,953.6
84	305.7253	243.6089	71,765.11	14,945.46	446.07	2.35	2.95	20.8	20.3	370,045	12,030.5
85	325.3705	259.5898	81,163.99	15,739.53	586.77	2.49	3.13	19.4	18.8	381,282	12,104.9
86	339.6853	269.3947	84,149.93	16,516.80	661.33	2.48	3.12	19.6	19.0	405,554	12,167.2
87	356.2636	281.7375	90,161.86	17,982.70	741.35	2.53	3.20	19.9	19.3	418,337	12,226.4
88	378.9630	299.3566	97,751.65	18,013.73	827.00	2.58	3.27	18.4	17.7	441,876	12,278.3
89	406.2449	318.3424	109,093.35	18,679.36	930.68	2.69	3.43	17.1	16.4	461,634	12,325.5
90	437.5818	-	-	-	1,042.68	-	-	-	-	484,346	12,361.2

Notes: 1. A= R&D expenditures as a percentage of gross national product, B= R&D expenditures as a percentage of national income, C= the ratio of R&D expenditures financed by government and D= the ratio of R&D expenditures financed by government excluding defense R&D expenditures.

2. R&D expenditures and the number of researchers are for natural sciences only. Including social sciences and humanities, R&D expenditures in FY1989 were 11,815,482 million yen (government-financed R&D expenditures of 2,202,420 million yen), A=2.91%, B=3.71%, C=18.6%, D=18.0% and the number of researchers in 1990 was 560,276 persons.

3. The numbers of researchers is as of April 1 in each year.

4. Defense-related R&D expenditures are appropriations to the Defense Agency in the science and technology budget of the government.

5. The numbers of population are those of national censuses and estimations as of October 1. The population of Okinawa Prefecture is not included in 1970 and 1971.

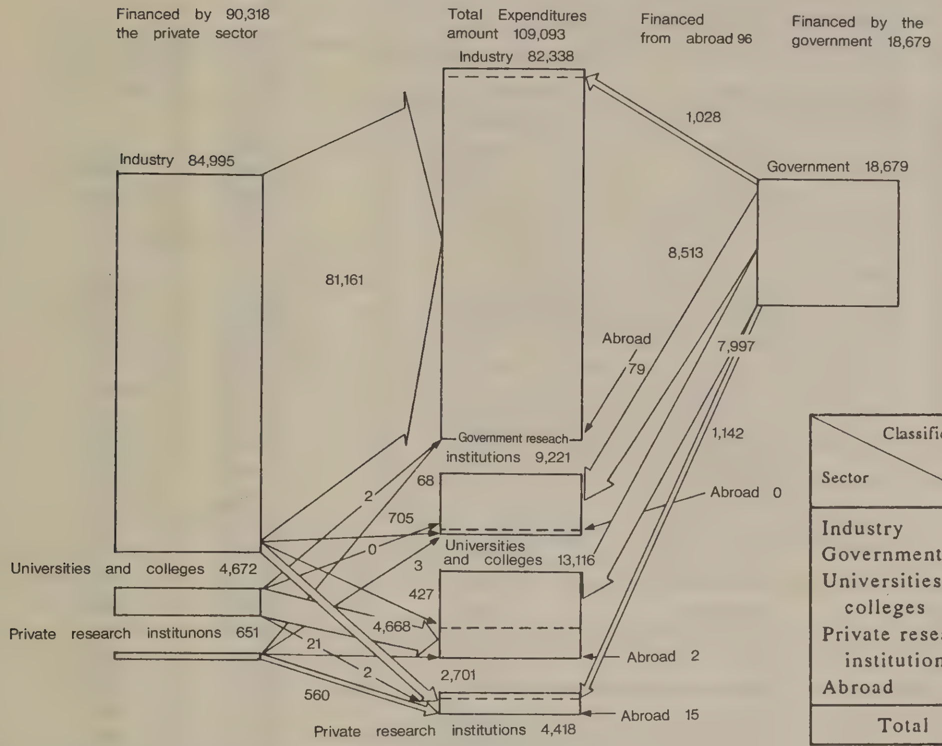
Sources: 1. Gross national product and national income: "Annual Report of National Accounts" by Economic Planning Agency.

2. R&D expenditures, government-financed expenditures and the number of researchers: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

3. Population: "Population Estimation Material" by the Statistics Bureau, Management and Coordination Agency.

2. Flow of R&D expenditures in Japan (in FY1989)

(100 million yen)



(%)

Sector \ Classification	Financing ratio	Performing ratio
Industry	77.9	75.5
Government	17.1	8.5
Universities and colleges	4.3	12.0
Private research institutions	0.6	4.0
Abroad	0.1	-
Total	100.0	100.0

Notes: 1. R&D expenditures are for natural sciences only.

2. R&D expenditures are the funds spent by research institutions themselves for research. There are two concepts of R&D expenditures on a performing basis:disbursement and cost. Japan considers R&D expenditures to be disbursements. Disbursement includes expenditures on labor, materials, tangible fixed assets, and so on. In case of cost, it is computed by adding the depreciation of tangible fixed assets instead of expenditures on the tangible fixed assets.

3. Coverage of each sector is as follows:

(1) Financing sector

1) Industry: companies and public corporations whose major purpose is not in research activities

2) Government: national and local governments, national, local government-owned research institutions, research-centered public corporations, and national and public universities and colleges (including junior colleges, same as in the following)

3) Universities and colleges: private universities and colleges (including junior colleges, same as in the following)

4) Private research institutions: nonprofit private research institutions

(2) Performing sector

1) Industry: coverage is the same as in the financing sector

2) Government research institutions:national and local government-owned research institutions and research-cenered public corporations

3) Universities and colleges: national public and private universities and colleges

4) Private research institutions: coverage is the same as in the financing sector

4. Because the figures both of financing and performing ratios have been rounded, the total of "sectors" does not always equal 100.0%.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

3. Changes in composition ratios of R&D expenditures by character of work in Japan

(%)

Classification / Fiscal Year	Industry			Government research institutions			Universities and colleges			Private research institutions			Total		
	Basic research	Applied research	Development	Basic research	Applied research	Development	Basic research	Applied research	Development	Basic research	Applied research	Development	Basic research	Applied research	Development
1970	9.3	27.2	63.5	17.4	42.7	39.9	-	-	-	22.3	35.8	41.9	23.3	27.6	49.1
71	9.1	25.9	65.0	19.6	33.5	47.0	-	-	-	22.2	36.4	41.4	23.9	25.8	50.2
72	8.1	22.3	69.6	15.0	32.5	52.4	-	-	-	22.5	57.0	20.5	22.5	23.6	53.9
73	6.7	19.5	73.8	15.6	29.0	55.4	-	-	-	16.4	53.4	30.1	21.5	21.3	57.2
74	6.3	19.4	74.3	16.5	38.2	45.3	75.4	18.5	6.1	7.2	16.4	76.4	15.0	21.7	63.3
75	5.2	19.1	75.8	15.8	34.3	49.9	70.9	21.6	7.5	6.5	21.1	72.4	14.2	21.5	64.3
76	5.0	18.6	76.3	18.1	34.6	47.3	56.4	38.2	5.3	9.7	26.6	63.7	16.6	24.7	58.8
77	4.7	19.6	75.7	18.1	35.5	46.5	57.4	37.0	5.7	13.5	30.0	56.5	16.2	25.1	58.7
78	4.6	18.2	77.1	18.5	34.9	46.6	57.3	37.3	5.4	12.2	61.6	26.2	16.6	25.1	58.4
79	4.6	19.5	75.9	18.9	37.1	44.0	55.2	38.1	6.7	14.5	63.8	21.7	15.5	25.9	58.7
80	5.0	19.5	75.5	15.8	39.3	44.9	55.8	37.0	7.2	12.6	46.0	41.4	14.5	25.4	60.0
81	5.2	21.8	73.0	14.2	32.2	53.6	55.8	36.3	8.0	9.9	36.7	53.3	13.9	25.7	60.4
82	5.5	21.9	72.6	14.3	31.8	53.9	54.9	37.6	7.4	8.5	33.1	58.4	14.1	25.9	60.1
83	5.7	22.0	72.3	13.9	30.7	55.4	54.9	36.9	8.3	9.2	31.4	59.4	14.0	25.4	60.6
84	5.6	22.0	72.4	13.9	29.9	56.2	54.9	36.6	8.5	11.1	31.7	57.2	13.6	25.1	61.3
85	5.9	21.9	72.1	13.0	28.5	58.4	54.2	37.4	8.4	10.6	33.5	55.9	12.9	25.0	62.2
86	6.1	21.6	72.3	13.6	27.3	59.1	54.2	37.4	8.4	14.1	27.8	58.1	13.3	24.4	62.3
87	6.6	21.7	71.7	14.6	28.3	57.1	54.2	37.4	8.4	18.3	20.8	60.9	14.0	24.3	61.7
88	6.6	21.7	71.7	13.5	26.8	59.7	52.8	38.5	8.7	18.0	22.3	59.8	13.3	24.3	62.4
89	6.4	21.5	72.2	13.1	27.3	59.6	53.2	38.1	8.7	19.7	22.5	57.8	12.8	23.9	63.2

Notes:1. For natural science only

2. Because the composition ratios by character or work were not surveyed for universities and colleges before FY1973, an estimate was made that basic research accounted for 80% and applied research for 20% and the "total" of the composition ratios thereby was calculated.

3. Figures of "Government research institutions", "universities and colleges" and "private research institutions" before FY1975 do not include values in the health field.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

4. Changes in R&D expenditures by financing sector in Japan

(million yen)

Classification / Fiscal Year	Total		National and local governments		Private sector		Abroad	
	R&D expenditures (A)	Ratio	Financing amount (B)	Ratio B/A	Financing amount (C)	Ratio C/A	Financing amount (D)	Ratio D/A
		%		%		%		%
1970	1,195,328	100	301,413	25.2	893,485	74.7	428	0.0
71	1,345,919	100	369,025	27.4	975,905	72.5	988	0.1
72	1,586,708	100	432,068	27.2	1,153,560	72.7	1,081	0.1
73	1,980,896	100	522,684	26.4	1,456,891	73.5	1,321	0.1
74	2,421,367	100	641,077	26.5	1,778,834	73.5	1,456	0.1
75	2,621,827	100	720,255	27.5	1,899,293	72.4	1,779	0.1
76	2,941,373	100	800,386	27.2	2,138,368	72.7	2,619	0.1
77	3,233,543	100	886,115	27.4	2,343,681	72.5	3,747	0.1
78	3,569,953	100	999,502	28.0	2,567,390	71.9	3,061	0.1
79	4,063,627	100	1,113,822	27.4	2,946,391	72.5	3,414	0.1
80	4,683,768	100	1,209,557	25.8	3,469,557	74.1	4,655	0.1
81	5,363,986	100	1,340,320	25.0	4,017,752	74.9	5,914	0.1
82	5,881,539	100	1,388,812	23.6	4,486,044	76.3	6,682	0.1
83	6,503,737	100	1,440,717	22.2	5,054,895	77.7	8,125	0.1
84	7,176,511	100	1,494,546	20.8	5,674,783	79.1	7,182	0.1
85	8,116,399	100	1,573,953	19.4	6,534,619	80.5	7,826	0.1
86	8,414,993	100	1,651,680	19.6	6,755,682	80.3	7,631	0.1
87	9,016,186	100	1,798,270	19.9	7,210,127	80.0	7,789	0.1
88	9,775,165	100	1,801,373	18.4	7,965,544	81.5	8,249	0.1
89	10,909,335	100	1,867,936	17.1	9,031,804	82.8	9,595	0.1

Note: Including social sciences and humanities, B/A in FY1989 is 18.6%.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

5. Changes in R&D expenditures by performing sector in Japan

(million yen)

Classification / Fiscal Year	Companies, etc.				Research Institutions						Universities and colleges					Total (D)	
	Companies	Public corporations (a)	Total (A)	Ratio A/D	National	Local government-owned	Private	Public corporations (b)	Total (B)	Ratio B/D	National	Public	Private	Total (C)	Ratio C/D		Ratio
				%						%					%		%
1970	785,010	138,255	823,265	68.9	51,560	54,239	14,598	34,222	154,619	12.9	131,760	15,995	69,689	217,444	18.2	1,195,328	100
71	845,790	49,230	895,020	66.5	58,035	63,920	18,721	59,790	200,466	14.9	143,129	18,593	88,710	250,433	18.6	1,345,919	100
72	985,925	59,002	1,044,928	65.9	68,018	72,145	19,414	93,298	252,885	15.9	158,872	19,922	110,102	288,896	18.2	1,586,708	100
73	1,238,444	63,483	1,301,927	65.7	82,266	90,645	24,320	123,509	320,740	16.2	187,809	23,466	146,954	358,229	18.1	1,980,896	100
74	1,524,114	64,939	1,589,053	65.6	102,996	110,142	74,727	99,208	387,073	16.0	245,135	27,052	173,054	445,241	18.4	2,421,367	100
75	1,616,211	68,726	1,684,847	64.3	117,596	111,460	72,684	118,595	420,699	16.0	284,293	29,574	202,414	516,281	19.7	2,621,827	100
76	1,808,210	74,021	1,882,231	64.0	123,403	118,222	84,867	144,997	471,489	16.0	317,986	31,877	237,790	587,564	20.0	2,941,373	100
77	2,019,851	89,649	2,109,500	65.2	140,618	143,141	71,013	150,573	494,345	15.3	351,945	35,745	242,007	629,698	19.5	3,233,543	100
78	2,194,252	96,750	2,291,002	64.2	155,684	137,285	82,447	190,917	566,333	15.9	399,275	35,676	277,667	712,618	20.0	3,569,953	100
79	2,559,917	104,995	2,664,913	65.6	177,704	150,877	76,119	216,331	621,032	15.3	434,641	39,081	303,960	777,683	19.1	4,063,627	100
80	3,032,145	110,111	3,142,256	67.1	185,372	165,966	122,533	243,742	717,612	15.3	461,765	41,374	320,761	823,900	17.6	4,683,768	100
81	3,517,034	112,759	3,629,793	67.7	191,956	177,702	213,394	265,783	848,834	15.8	505,040	45,516	334,803	885,359	16.5	5,363,986	100
82	3,917,089	121,929	4,039,018	68.7	195,747	177,766	244,198	276,599	894,310	15.2	529,884	47,081	371,245	948,211	16.1	5,881,539	100
83	4,435,361	124,766	4,560,127	70.1	200,863	178,222	248,087	288,082	915,254	14.1	561,246	49,491	417,620	1,028,356	15.8	6,503,737	100
84	5,114,631	22,003	5,136,634	71.6	208,062	185,658	274,987	307,396	976,102	13.6	585,463	52,182	426,130	1,063,775	14.8	7,176,511	100
85	5,913,942	26,005	5,939,947	73.2	227,454	193,052	316,461	364,704	1,101,041	13.6	589,212	56,310	429,888	1,075,410	13.2	8,116,399	100
86	6,105,886	14,277	6,120,163	72.7	236,700	193,568	360,436	382,261	1,172,966	13.9	610,800	57,532	453,532	1,121,864	13.3	8,414,993	100
87	6,480,897	13,370	6,494,268	72.0	297,419	201,313	398,324	415,283	1,312,340	14.6	659,914	61,932	487,733	1,209,579	13.4	9,016,186	100
88	7,202,873	16,446	7,219,318	73.9	262,093	208,552	411,511	434,140	1,316,296	13.5	675,343	61,927	502,281	1,239,551	12.6	9,775,165	100
89	8,217,138	16,682	8,233,820	75.5	273,061	226,075	441,818	422,930	1,363,884	12.5	705,507	74,274	531,850	1,311,631	12.0	10,909,335	100

Notes: 1. Public corporations (a) are those which are operated on a self-paying basis and public corporations (b) are those which are not expected to operate on a self-paying basis.

2. In FY1974, research associations based on the Research Associations for Mining and Manufacturing Technology Law were rearranged from public corporations (b) into private research institutions.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

6. Changes in composition ratios of R&D expenditures by constituent elements in Japan

(%)

	Fiscal Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Companies	Labor cost	46.2	44.2	43.3	43.5	42.1	40.7	41.3	41.4	40.7	39.4
	Materials cost	18.7	19.9	19.8	19.6	20.5	20.5	20.5	20.3	20.9	21.1
	Expenditure on tangible fixed assets	15.1	16.0	15.9	15.4	15.5	6.5	15.7	15.6	14.7	15.6
	Other expenses	20.1	19.9	20.9	21.4	22.0	22.4	22.5	22.8	23.8	23.8
	Total	100	100	100	100	100	100	100	100	100	100
Research institutions	Labor cost	36.5	34.9	34.8	35.3	35.4	33.1	33.2	30.7	32.5	32.6
	Materials cost	11.1	12.6	13.3	12.6	13.6	14.6	17.4	16.2	17.5	17.6
	Expenditure on tangible fixed assets	30.4	29.9	28.0	25.8	27.2	29.2	26.9	29.8	26.7	24.2
	Other expenses	21.9	22.6	23.9	26.3	23.9	23.0	22.4	23.3	23.3	25.6
	Total	100	100	100	100	100	100	100	100	100	100
Universities and colleges	Labor cost	58.7	58.0	57.8	57.1	59.3	60.4	61.0	59.8	61.0	60.3
	Materials cost	7.6	8.9	9.2	8.4	8.8	8.7	8.7	8.5	9.0	9.3
	Expenditure on tangible fixed assets	20.0	19.2	18.9	19.4	18.0	16.0	16.0	17.2	15.5	16.0
	Other expenses	13.7	13.9	14.0	15.2	14.0	14.9	14.3	14.5	14.5	14.5
	Total	100	100	100	100	100	100	100	100	100	100
Total	Labor cost	46.9	45.0	44.4	44.5	43.7	42.3	42.8	42.3	42.2	41.1
	Materials cost	15.5	16.9	17.1	16.9	17.8	18.1	18.5	18.1	18.9	19.3
	Expenditure on tangible fixed assets	18.3	18.8	18.2	17.5	17.5	18.1	17.3	17.9	16.4	16.7
	Other expenses	19.2	19.3	20.3	21.1	21.0	21.5	21.4	21.7	22.5	22.9
	Total	100	100	100	100	100	100	100	100	100	100

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

7. Changes in number of personnel engaged in R&D activities in Japan

(person)

Year	Number of R&D performing institutions	Personnel engaged in R&D activities		Researcher		Assistant research workers		Technicians		Clerical and other supporting personnel	
			%		%		%		%		%
1970	12,594	392,236	100	172,002	43.9	75,363	19.2	88,282	22.5	56,589	14.4
71	18,935	429,348	100	194,347	45.3	80,194	18.7	93,581	21.8	61,226	14.3
72	15,753	426,935	100	198,084	46.4	82,308	19.3	86,149	20.2	60,394	14.1
73	13,253	459,239	100	226,604	49.3	80,720	17.6	88,857	19.3	63,058	13.7
74	11,614	468,060	100	238,179	50.9	79,400	17.0	87,516	18.7	62,965	13.5
75	14,445	491,296	100	255,202	51.9	81,934	16.7	90,468	18.5	63,512	12.9
76	14,552	487,999	100	260,250	53.3	79,245	16.2	89,089	18.3	59,415	12.2
77	13,693	492,287	100	271,956	55.2	73,794	15.0	86,698	17.6	59,839	12.2
78	17,289	486,776	100	273,102	56.1	72,479	14.9	83,321	17.1	57,874	11.9
79	16,269	496,030	100	281,920	56.8	72,988	14.7	82,163	16.6	58,959	11.9
80	19,618	521,119	100	302,585	58.1	72,918	14.2	85,882	16.5	58,734	11.3
81	19,103	548,312	100	317,487	57.9	79,889	14.6	89,326	16.3	61,610	11.2
82	18,026	567,235	100	329,728	58.1	83,592	14.7	90,072	15.9	63,843	11.3
83	17,214	587,182	100	342,237	58.3	86,630	14.8	92,224	15.7	66,091	11.3
84	19,367	627,814	100	370,045	58.9	92,826	14.8	96,109	15.3	68,834	11.0
85	16,663	646,299	100	381,282	59.0	97,263	15.0	98,267	15.2	69,487	10.8
86	16,263	676,023	100	405,554	60.0	98,493	14.6	100,850	14.9	71,126	10.5
87	15,449	691,882	100	418,337	60.5	99,569	14.4	101,492	14.7	72,424	10.5
88	16,100	715,337	100	441,876	61.8	98,449	13.8	101,960	14.3	73,002	10.2
89	16,657	740,438	100	461,634	62.3	98,846	13.3	104,497	14.1	75,461	10.2
90	16,625	769,696	100	484,346	62.9	103,077	13.4	103,192	13.4	79,081	10.3

Note: Figures are as of April 1 in each year
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

8. Changes in number of researchers by sector in Japan

(person)

Classification / Year	Companies, etc.				Research institutions						Universities and colleges					Total (D)	
	Companies	Public corporations(a)	Total (A)	Ratio A/D	National	Local government-owned	Private	Public corporations (b)	Total (B)	Ratio B/D	National	Public	Private	Total (C)	Ratio C/D		Ratio
				%						%					%		%
1970	91,516	2,544	94,060	54.7	8,826	11,149	1,465	1,262	22,702	13.2	34,064	4,536	16,640	55,240	32.1	172,002	100
71	108,593	2,651	111,244	57.2	9,187	11,333	1,534	1,302	23,356	12.0	35,679	4,597	19,471	59,747	30.7	194,347	100
72	100,017	2,746	112,763	56.9	9,231	12,284	1,734	1,569	24,818	12.5	36,168	4,415	19,920	60,503	30.5	198,084	100
73	121,797	2,998	124,795	55.1	9,327	13,012	1,769	2,542	26,650	11.8	43,648	6,940	24,571	75,159	33.3	226,604	100
74	127,536	3,154	130,690	54.9	9,206	13,848	1,824	3,412	28,290	11.9	46,362	6,605	26,232	79,199	33.3	238,179	100
75	143,364	3,240	146,604	57.4	9,341	13,732	1,775	1,842	26,690	10.5	46,771	6,648	28,489	81,908	32.1	255,202	100
76	142,554	2,662	145,216	55.8	9,341	13,698	2,048	1,923	27,010	10.4	50,695	7,120	30,209	88,024	33.8	260,250	100
77	148,741	2,696	151,437	55.7	9,421	13,760	2,654	1,905	27,740	10.2	53,110	7,559	32,110	92,779	34.1	271,956	100
78	150,924	2,782	153,706	56.3	9,712	13,857	2,342	1,997	27,888	10.2	52,019	7,124	32,365	91,508	33.5	273,102	100
79	154,447	2,832	157,279	55.8	9,724	13,737	2,377	2,079	27,917	9.9	54,086	7,154	35,484	96,724	34.3	281,920	100
80	170,279	2,965	173,244	57.3	9,895	13,988	2,512	2,246	28,641	9.5	57,434	7,342	35,924	100,700	33.3	302,585	100
81	181,892	2,997	184,889	58.2	10,073	14,110	3,412	2,411	30,006	5.5	57,523	7,395	37,674	102,592	32.3	317,487	100
82	189,952	2,990	192,942	58.2	10,067	14,257	5,901	2,449	32,674	9.9	58,340	7,612	38,160	104,112	31.6	329,728	100
83	198,132	3,005	201,137	58.8	10,217	13,907	4,514	2,532	31,170	9.1	60,774	8,171	40,985	109,930	32.1	342,237	100
84	220,835	3,047	223,882	60.5	10,179	13,958	5,376	2,467	31,980	8.6	62,906	8,400	42,877	114,183	30.9	370,045	100
85	230,445	652	231,097	60.6	10,037	13,994	5,649	2,487	32,167	8.4	64,657	8,616	44,745	118,018	31.0	381,282	100
86	251,138	633	251,771	62.1	10,169	13,843	5,902	2,545	32,459	8.0	65,926	8,714	46,684	121,324	29.9	405,554	100
87	260,457	389	260,846	62.4	10,016	13,748	6,715	2,688	33,257	7.9	67,590	8,974	47,670	124,234	29.7	418,337	100
88	278,904	394	279,298	63.2	10,174	13,578	7,809	2,908	34,469	7.8	69,787	9,100	49,222	128,109	29.0	441,876	100
89	293,789	413	294,202	63.7	10,225	13,698	8,839	2,948	35,710	7.7	71,614	9,402	50,706	131,722	28.5	461,634	100
90	313,527	421	313,948	64.8	10,195	13,713	9,259	3,098	36,265	7.5	73,471	9,468	51,194	134,133	27.7	484,346	100

Notes: 1. Figures are as of April 1 in each year.
2. Classification of public corporations (a) and (b) is the same as in Appendix 5.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

9. R&D expenditures and number of researchers of companies, etc. by industry in Japan

(1) R&D expenditures per researcher (in FY1989)

Industry	Number of companies, etc. conducting research activities	Research expenditures performed	Number of researchers	Research expenditures per researcher
		million yen	person	million yen
All industries	14,704	8,233,820	294,202	27.99
Agriculture, forestry and fisheries	16	4,419	286	15.45
Mining	119	24,570	733	33.52
Construction	1,611	185,147	7,272	25.46
Manufacturing	12,889	7,706,193	281,247	27.40
Food	1,202	203,596	9,373	21.72
Textiles	530	81,263	3,413	23.81
Pulp and paper products	267	45,487	1,987	22.89
Printing and publishing	138	33,721	1,497	22.53
Chemicals	1,,638	1,313,882	49,170	26.72
Petroleum and coal products	106	84,199	1,977	42.59
Plastic products	429	120,758	4,237	28.50
Rubber products	156	111,784	4,210	26.55
Ceramics	548	221,424	7,453	29.71
Iron and steel	149	268,131	5,905	45.41
Non-ferrous metals and products	232	127,043	4,216	30.13
Fabricated metal products	1,289	109,324	5,090	21.48
General machinery	2,418	558,974	24,677	22.65
Electrical machinery	1,996	2,808,123	112,387	24.99
Transport equipment	483	1,244,625	27,993	44.46
Precision instruments	548	266,110	12,374	21.51
Other manufacturing	760	107,750	5,288	20.38
Transport, communication and public utility	69	313,492	4,664	67.22

Note: The number of companies, etc. conducting research activities is the number of companies, etc. which conducted research activities in FY1989. The number of researchers is as of April 1, 1989.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

(2) Number of researchers per 10-thousand employees (in 1990)

Industry	Number of researchers	Composition ratio in the number of researchers	Number of employees of companies, etc. conducting R&D activities	Number of researchers per 10-thousand employees
	persons	%	persons	persons
All industries	313,948	100.0	6,597,213	476
Agriculture, forestry and fisheries	252	0.1	14,722	171
Mining	680	0.2	27,027	252
Construction	7,533	2.4	558,017	135
Manufacturing	300,377	95.7	5,204,400	577
Food	9,422	3.0	409,105	230
Textiles	3,929	1.3	140,452	280
Pulp and paper products	2,165	0.7	107,489	201
Printing and publishing	1,246	0.4	91,850	136
Chemicals	52,196	16.6	556,703	938
Petroleum and coal products	1,999	0.6	43,890	455
Plastic products	4,050	1.3	107,531	377
Rubber products	4,945	1.6	102,811	481
Ceramics	7,716	2.5	207,430	372
Iron and steel	5,946	1.9	240,632	247
Non-ferrous metals and products	4,136	1.3	118,671	349
Fabricated metal products	6,446	2.1	252,618	255
General machinery	27,382	8.7	580,322	472
Electrical machinery	119,386	38.0	1,220,187	978
Transport equipment	29,383	9.4	660,575	445
Precision instruments	13,796	4.4	166,013	831
Other manufacturing	6,234	2.0	198,121	315
Transport, communication and public utility	5,106	1.6	793,047	64

Note: Figures are as of April 1, 1990.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

10. Changes in ratio of company R&D expenditures to sales figures in Japan

(%)

Industry \ Fiscal year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
All industries	1.48	1.62	1.78	1.97	1.99	2.31	2.57	2.59	2.60	2.72
Agriculture, forestry and fisheries	0.17	0.26	0.27	0.26	0.24	0.24	0.24	0.31	0.38	0.21
Mining	0.52	0.46	0.64	0.59	0.63	1.03	1.16	1.01	1.27	0.94
Construction	0.46	0.37	0.43	0.53	0.47	0.49	0.55	0.51	0.49	0.52
Manufacturing	1.73	1.91	2.15	2.31	2.34	2.69	3.03	3.14	3.15	3.29
Food	0.58	0.55	0.63	0.70	0.60	0.77	0.85	0.99	0.89	1.07
Textiles	0.77	1.09	1.13	0.90	1.16	1.18	1.23	1.42	1.50	1.71
Pulp and paper products	0.41	0.43	0.52	0.63	0.66	0.71	0.80	0.77	0.87	0.79
Printing and publishing	0.26	0.21	0.39	0.43	0.61	0.68	0.64	0.80	0.63	0.71
Chemicals	2.55	2.87	3.05	3.34	3.46	3.79	4.31	4.53	4.63	4.84
Industrial chemicals and chemical fibers	1.85	2.01	2.17	2.32	2.47	2.80	3.56	3.76	3.92	4.09
Oils and paints	2.48	2.56	2.66	2.83	3.09	3.14	3.42	3.85	3.74	3.93
Drugs and medicines	5.45	5.85	5.56	6.59	6.49	7.04	6.89	6.96	6.94	7.50
Other chemicals	2.19	3.03	3.43	3.40	3.76	3.61	3.87	4.00	4.11	4.11
Petroleum and coal products	0.30	0.18	0.20	0.26	0.27	0.38	0.62	0.64	0.83	0.72
Plastic products	-	-	-	-	1.94	1.75	2.09	2.16	2.21	2.73
Rubber products	2.10	2.33	2.47	2.40	2.62	2.86	2.92	3.25	3.19	3.25
Ceramics	1.30	1.39	1.64	1.82	1.96	2.61	2.87	2.82	2.73	2.75
Iron and steel	1.14	1.30	1.50	1.60	1.52	1.94	2.54	2.40	2.13	2.21
Non-ferrous metals and products	1.03	1.36	1.57	1.49	1.64	1.92	2.11	1.90	2.00	1.91
Fabricated metal products	1.15	1.22	1.43	1.31	1.46	1.59	1.61	1.50	1.48	1.36
General machinery	1.90	2.10	2.34	2.57	2.59	2.74	2.77	2.99	2.60	2.83
Electrical machinery	3.71	4.06	4.52	4.70	4.55	5.10	5.50	5.61	5.53	5.89
Electrical machinery,equipment and supplies	3.35	3.80	4.17	4.40	4.45	4.82	5.23	5.26	5.25	5.47
Communication and electronics equipment	3.94	4.21	4.72	4.85	4.60	5.25	5.63	5.78	5.66	6.10
Transport equipment	2.34	2.62	2.69	2.66	2.76	2.90	3.21	3.22	3.31	3.40
Motor vehicles	2.38	2.82	3.02	2.89	2.90	2.96	3.20	3.17	3.31	3.48
Other transport equipment	2.15	1.94	1.67	1.86	2.20	2.61	3.28	3.45	3.31	2.93
Precision instruments	3.02	3.47	3.97	4.02	4.08	4.49	4.59	4.91	4.85	5.16
Other manufacturing	1.16	1.11	1.30	1.30	0.92	0.97	1.07	1.12	1.14	1.19
Transport, communication and public utilities	0.32	0.39	0.32	0.36	0.84	0.98	0.96	0.84	0.95	1.06

Notes: 1. Figures are the ratio of R&D expenditures spent by themselves to sales amount.
2. Figures are for companies only, excluding public corporations.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

11. Changes in Japan's technology trade amounts

(100 million yen)

Year \ Classification	Export (A)	Import (B)	Ratio A/B
1970	197	1,479	0.13
71	213	1,638	0.13
72	212	1,655	0.13
73	231	1,850	0.12
74	324	2,153	0.15
75	421	2,069	0.20
76	519	2,373	0.22
77	548	2,647	0.21
78	594	2,460	0.24
79	703	2,791	0.25
80	803	3,011	0.27
81	1,063	3,775	0.28
82	1,392	4,369	0.32
83	1,351	4,707	0.29
84	1,651	5,401	0.31
85	1,724	5,631	0.31
86	1,527	5,454	0.22
87	1,870	5,515	0.34
88	2,098	6,429	0.33
89	2,782	7,347	0.38
90	3,589	8,744	0.41

Note: Figures are values in each calendar year
Source: The Bank of Japan, "Balance of Payments Monthly"

12. Changes in technology trade amounts by industry in Japan

(1) Technology export amounts

Industry \ Fiscal Year	1980	1981	1982	1983	1984
All industries	159,612	175,106	184,921	240,887	277,512
Manufacturing	133,274	151,783	164,058	209,699	231,860
Food	2,169	3,689	4,720	3,640	6,820
Textiles	3,169	4,929	6,256	2,189	3,855
Chemicals	31,876	31,951	29,409	31,443	37,502
Ceramics	7,989	4,817	6,271	9,642	11,238
Iron and steel	17,856	24,501	29,047	40,151	32,395
Non-ferrous metals and products	3,663	2,057	3,034	2,349	1,924
Fabricated metal products	1,221	914	1,862	1,529	1,275
General machinery	9,621	5,336	5,249	10,717	11,396
Electrical machinery	23,045	28,666	35,484	35,551	47,150
Transport equipment	21,758	27,693	28,698	28,951	39,784
Precision instruments	873	2,900	2,418	4,037	1,802
Other manufacturing	10,033	14,331	11,611	39,500	36,721
Construction	25,399	22,326	19,145	29,955	14,638
Other non-manufacturing	938	996	1,781	1,233	1,014

(2) Technology import amounts

Industry \ Fiscal Year	1980	1981	1982	1983	1984
All industries	239,529	259,632	282,613	279,280	281,447
Manufacturing	233,185	255,606	278,075	272,838	276,895
Food	9,642	10,609	11,286	8,690	9,480
Textiles	2,233	8,722	2,821	5,543	9,447
Chemicals	39,252	37,110	45,860	42,280	40,765
Ceramics	9,612	10,237	10,759	6,731	8,378
Iron and steel	8,023	14,808	7,800	17,581	5,562
Non-ferrous metals and products	3,690	3,623	3,396	3,651	5,100
Fabricated metal products	4,440	2,816	3,057	2,601	3,606
General machinery	30,209	30,810	27,405	28,493	23,905
Electrical machinery	61,676	68,814	89,158	91,921	94,907
Transport equipment	40,274	48,674	56,413	46,916	55,243
Precision instruments	2,948	3,769	3,515	4,405	4,386
Other manufacturing	21,185	15,613	16,606	14,027	16,116
Construction	2,707	2,918	2,298	4,397	2,294
Other non-manufacturing	3,637	1,109	2,239	2,046	2,258

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

(million yen)

1985	1986	1987	1988	1989				
					Composition ratio (%)	Ratio to the previous year	Amounts per one contract (million yen)	Percentage of receipts to R&D expenditures (%)
234,220	224,078	215,575	246,255	329,348	100	1.34	43.6	5.4
205,588	193,483	200,772	228,557	316,241	96.0	1.38	43.4	5.5
6,139	4,945	4,982	5,787	8,337	2.5	1.44	58.7	9.1
4,001	4,633	4,385	4,361	4,648	1.4	1.07	13.0	8.8
38,233	38,235	39,295	48,100	53,616	16.3	1.11	41.3	5.8
9,450	5,468	6,194	5,723	9,025	2.7	1.58	35.8	6.4
26,195	21,540	9,993	10,798	21,572	6.5	2.00	39.2	8.8
1,947	3,586	2,614	2,011	7,054	2.1	3.51	26.4	6.7
2,394	1,525	1,291	1,147	2,004	0.6	1.75	4.9	5.1
11,714	6,806	8,741	10,818	13,210	4.0	1.22	17.0	4.6
59,460	53,001	61,126	68,795	86,708	26.3	1.26	52.0	3.8
32,386	43,840	49,213	58,404	87,126	26.5	1.49	112.1	7.6
1,725	1,850	2,921	4,611	12,556	3.8	2.72	39.2	6.8
11,946	8,055	10,017	8,002	10,385	3.2	1.30	22.2	3.6
26,530	20,835	12,801	16,797	12,448	3.8	0.74	56.8	18.1
2,101	9,759	2,002	901	659	0.2	0.73	12.2	0.3

(million yen)

1985	1986	1987	1988	1989				
					Composition ratio (%)	Ratio to the previous year	Amounts per one contract (million yen)	Percentage of payments to R&D expenditures (%)
293,173	260,577	283,245	312,195	329,925	100	1.06	46.4	5.4
288,628	258,393	280,996	309,490	326,901	99.1	1.06	48.2	5.5
10,422	10,793	9,785	13,397	8,471	2.6	0.63	91.1	11.0
3,287	3,246	3,683	4,910	4,847	1.5	0.99	51.0	12.4
37,387	40,583	40,554	50,335	56,866	17.2	1.13	60.4	6.2
32,404	6,589	6,554	3,735	4,092	1.2	1.10	23.5	2.9
4,698	5,780	8,013	7,867	4,776	1.4	0.61	14.9	2.0
5,078	4,158	10,719	14,619	10,702	3.2	0.73	48.4	10.8
3,922	3,091	2,901	2,166	2,279	0.7	1.05	14.8	7.9
24,483	25,413	21,298	22,592	32,986	10.0	1.46	26.0	11.0
84,197	91,264	109,455	113,778	120,553	36.5	1.06	66.1	4.9
59,704	49,045	48,751	51,955	54,912	16.6	1.06	67.0	5.0
5,059	4,154	6,677	7,265	8,302	2.5	1.14	28.6	4.0
17,987	14,275	12,606	16,871	18,115	5.5	1.07	31.6	5.1
3,476	1,755	934	966	2,043	0.6	2.11	7.0	2.2
1,070	428	1,036	1,739	981	0.3	0.56	22.8	2.3

13. Changes in technology trade amounts of Japan by region and country

(1) Technology export amounts

(100 million yen)

Region and country \ Fiscal year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Composition ratio (%)	Ratio to the previous year
Asia (excluding West Asia)	542.18	679.04	707.67	1,019.20	1,125.16	875.23	864.81	864.35	1,014.12	1,288.62	39.13	1.27
West Asia	244.13	101.57	56.97	173.00	307.83	141.13	104.85	15.88	22.77	23.60	0.72	1.04
North America	295.01	383.26	406.19	600.34	719.15	587.40	622.88	725.02	769.76	1,151.36	34.96	1.50
South America	108.42	117.70	108.03	100.63	36.54	87.40	51.61	44.60	44.43	45.80	1.39	1.03
Europe	290.46	321.49	389.63	370.53	407.07	454.61	435.98	402.61	492.62	650.67	19.76	1.32
Africa and Oceania	115.91	148.00	178.72	145.13	179.36	196.44	160.65	103.29	118.84	133.43	4.05	1.12
Total	1,596.12	1,751.06	1,849.21	2,408.87	2,775.12	2,342.20	2,240.78	2,155.75	2,462.55	3,293.48	100	1.34
Korea	53	95	75	170	149	182	211	275	306	385	11.68	1.26
China (including Taiwan)	194	168	142	292	531	343	282	217	216	244	7.40	1.13
(Taiwan)	99	120	97	108	100	79	85	123	132	163	4.93	1.23
Indonesia	76	108	148	158	136	94	152	85	103	109	3.30	1.05
Thailand	42	50	56	61	83	62	54	73	99	176	5.34	1.78
Singapore	81	121	71	78	91	61	48	66	121	161	4.89	1.33
U S A	221	326	356	536	659	518	577	659	711	1,077	32.71	1.52
Brazil	29	74	73	79	19	33	38	25	25	33	0.99	1.30
U K	21	26	84	53	68	53	76	106	139	200	6.07	1.43
Italy	37	45	88	73	57	51	72	37	48	39	1.19	0.83
U S S R	48	24	20	19	11	24	5	27	45	89	2.70	1.96
Germany	34	29	47	51	47	113	78	74	107	137	4.16	1.28
France	23	45	39	45	46	48	59	52	44	71	2.17	1.61
Australia	27	45	46	31	41	119	58	42	52	57	1.73	1.10

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

(2) Technology import amounts

(100 million yen)

Fiscal year / Region and country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989		
											Composition ratio (%)	Ratio to the previous year
North America	1,568.62	1,739.01	1,885.61	1,940.00	1,939.89	2,102.79	1,745.51	1,792.51	1,984.27	2,107.41	63.88	1.06
Europe	821.27	844.25	926.62	844.99	866.98	815.67	851.37	1,034.17	1,136.02	1,181.63	35.82	1.04
Others	5.40	13.05	13.90	7.81	7.60	13.27	8.88	5.78	4.65	10.20	0.31	2.19
Total	2,395.29	2,596.32	2,826.13	2,792.80	2,814.47	2,931.73	2,605.77	2,832.45	3,121.95	3,299.25	100	1.06
U S A	1,538	1,718	1,870	1,911	1,930	2,086	1,738	1,786	1,969	2,095	63.50	1.06
U K	202	180	250	147	132	146	130	103	993	108	3.29	1.16
Italy	13	17	18	12	48	15	22	12	23	25	0.77	1.08
Netherlands	63	100	127	113	141	155	156	208	276	211	6.38	0.76
Switzerland	155	154	157	159	160	163	175	174	184	190	5.77	1.04
Germany	205	189	178	196	178	176	207	214	184	243	7.35	1.31
France	111	103	109	114	104	68	73	221	262	255	7.74	0.97

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

14. Japan's technology trade amounts by industry and region (in FY1989)

(million yen)

Item	Export amounts							Import amounts			
	Total	Asia(excluding West Asia)	West Asia	North America	South America	Europe	Others	Total	North America	Europe	Others
All industries	329,348	128,862	2,360	115,136	4,580	65,067	13,343	329,925	210,741	118,163	1,020
Construction	12,448	9,978	435	253	244	47	1,490	2,043	566	1,039	438
Manufacturing	316,241	118,581	1,858	114,775	4,185	65,005	11,836	326,901	209,439	116,880	582
Food	8,337	2,463	-	4,110	123	1,642	X	8,471	2,631	5,840	-
Textiles	4,648	3,425	-	436	-	769	X	4,847	853	3,994	-
Pulp and paper products	555	106	-	175	X	211	X	1,318	891	427	-
Printing and publishing	445	200	X	141	X	50	X	1,579	1,500	80	X
Chemicals	53,616	15,940	689	23,222	1,057	12,342	366	56,866	31,012	25,790	64
Petroleum and coal products	487	422	-	X	X	X	X	3,752	1,983	1,769	X
Plastic products	1,168	499	-	372	-	285	X	1,340	788	540	X
Rubber products	4,804	2,170	X	988	X	1,006	301	3,787	1,751	2,035	-
Ceramics	9,025	7,300	X	734	31	702	271	4,092	2,757	1,335	X
Iron and steel	21,572	2,640	465	5,170	1,312	9,378	2,607	4,776	1,641	3,098	X
Non-ferrous metals and products	7,054	1,601	-	4,887	215	262	90	10,702	3,847	6,848	X
Fabricated metal products	2,004	1,131	X	398	-	413	61	2,279	748	1,500	X
General machinery	13,210	5,133	24	4,447	71	3,387	148	32,986	20,520	12,407	59
Electrical machinery	86,708	42,614	207	20,681	970	21,145	1,090	120,553	87,757	32,779	17
Transport equipment	87,126	28,330	104	42,292	256	9,261	6,883	54,912	41,078	13,698	135
Precision instruments	12,556	3,203	-	5,663	-	3,688	X	8,302	5,980	2,210	113
Other manufacturing	2,926	1,402	-	1,059	X	423	X	6,339	3,702	2,530	X
Others	659	303	67	108	151	14	17	981	736	244	-

Note: " - " indicates "none" and "X" shows that values are not expressed because the number of contracts is not more than 4.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

15. Deflators of R&D expenditures in Japan

Fiscal year \ Sector	Natural sciences: Companies, etc.	Natural sciences: Research institutions	Natural sciences: Universities and colleges	Natural sciences: Total	Total including social sciences and humanities
1970	38.7	39.6	34.6	38.3	37.0
71	40.4	41.3	36.9	40.1	38.9
72	43.3	44.2	40.5	43.1	42.2
73	52.1	53.3	48.5	51.8	50.9
74	64.6	65.3	60.4	64.1	63.0
75	68.9	69.0	65.2	68.4	67.3
76	74.3	74.3	71.0	73.9	72.9
77	77.4	77.4	75.0	77.1	76.4
78	78.7	79.1	77.4	78.6	78.2
79	85.4	85.4	83.0	85.1	84.4
80	92.4	92.2	88.8	91.9	91.1
81	95.2	94.9	92.2	94.8	94.2
82	97.5	97.2	95.2	97.2	96.7
83	98.0	97.8	96.4	97.8	97.5
84	100.0	99.8	98.8	99.8	99.6
85	100.0	100.0	100.0	100.0	100.0
86	97.3	98.0	99.4	97.7	98.0
87	97.8	98.7	100.5	98.3	98.7
88	99.9	100.9	103.6	100.5	101.0
89	104.1	105.4	108.3	104.8	105.3
90	-	-	-	-	-

Source: The Statistics Bureau, Management and Coordination Agency

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